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Seasonal Changes in the Chemical Composition of Range Forage and Their Relation to Nutrition of Animals

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SEASONAL CHANGES IN THE CHEMICAL COMPOSITION OF RANGE FORAGE AND THEIR RELATION TO NUTRITION OF ANIMALS[1,2]

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INTRODUCTION

Field observations in California have shown that there is great variability in the nutritive value of forage in different areas as well as seasonal variations in the value of individual species. The present study discusses the nutritive requirements of livestock in relation to the character and quality of the feed supply. It was desired to ascertain the limiting nutritional factors in the forage in order to establish a basis for supplementing the range to obtain the most efficient reproduction, growth, and fattening of food animals.

The principal forage plants of California foothill and valley ranges are annuals which germinate with the coming of fall rains and make a varied amount of growth during the winter, depending on temperature and moisture conditions. From February to May is usually the period of greatest growth. With cessation of rain and depletion of soil moisture, the plants mature and dry. After this time the forage is subject to bleaching throughout the remainder of the dry season, until fall or winter rains bring on new feed. In general, cattle are either maintained on these ranges throughout the year or move to high mountain ranges for a three to five months' period, extending usually from June to October.

In the manufacture of material in the leaves and stems of plants, carbon, hydrogen, and oxygen are important elements which are drawn from the atmosphere and water supply. Even the all-important nitrogen can be taken from the air and fixed in the soil by certain soil

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[2] The experimental work reported in this paper became cooperative with the United States Bureau of Animal Industry July 1, 1929.

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bacteria and, to a small extent, is carried by rain into the soil in the form of ammonia. From these four elements as a basis, the great mass of organic compounds in plants is chiefly built up. With respect to inorganic compounds, however, soils over more or less wide areas become depleted of compounds of phosphorus, calcium, potassium, chlorine, sulfur, iodine, copper, iron, magnesium, manganese, and other elements; and deficiencies of these elements affect the growth of plants and their nutritive value for livestock.

Evidence now available shows that even the dry, bleached, and leached forage constitutes a cheap source of energy for livestock when its deficiencies are supplied by supplements. The appetites of the animals appear to be improved, the result being greater consumption of feed and less selective grazing. This is a common observation when cotton seed cake is fed. This study has shown that it is not profitable to allow the natural forage to become depleted and to let the animals become thin before giving supplements; but, rather, one should supplement sufficiently in order to maintain the animals in strong condition and still have ample forage available to the end of the season. It is generally a good practice to have a residual stand of dry feed as a cover for the new growth.

The supplements contain valuable ingredients for fertilization, part of which pass out with the manure. In this way elements, particularly minerals, which are carried off the range each year in the skeletons of feeder or finished cattle, may be partially returned to the soil.

Volumes have been written regarding the effects of overgrazing, the consequent reduction in water storage, and the increased erosion from the loss of the vegetative cover on the land. There has been a change in the flora on our California ranges, perennial forage plants having largely disappeared and been replaced by annuals.

In the study of our ranges it is important to consider the forage stand and its composition in relation to livestock grazing. In this connection, Shelford[1] has recently attacked the fundamental concepts of some plant ecologists who apparently consider and name the vegetation apart from the animals. These investigators have desired to learn the ultimate climax of vegetation with the presence of wild animals or with equivalent domestic animals excluded by fencing rather than reduced to the early or original numbers. The purpose of Shelford's paper was to restate the unity of the plant-animal community and suggest principles that make such a concept tenable, and expressed by him as follows:

> That a much broader and more flexible view of controlling factors is tenable than the one which holds that the animals are merely an environmental factor acting upon plants. That food relations, especially of abundant and influent animals, are usually

flexible and rarely if ever obligate; and that observation of apparently restricted food relations made in one locality may not hold good under other conditions. That the climaxes of nature (bioecological climax) include that vegetation which occurs with the pristine numbers and kinds of animals present.

Regarding bioecological climaxes, Shelford claims that if bison held some of the mixed prairie to the short grass stage, then short grass was the bioecological climax, even though the climax with bison excluded would have been quite different.

From the plant side a really comprehensive study of pastures would enter the fields of botany, soil science, plant nutrition, and plant breeding. From the animal side, in order to ascertain the value of the forage for the nutrient requirements of the growing, breeding, lactating, or fattening animal, we would enter the fields of biochemistry, physiology, and pathology.

This study approaches the question from the animal side. The nutritive value of natural vegetation, on different soils and at different stages of its growth, must be better understood if livestock production is to continue profitable. Such knowledge is the key to the efficient feeding of supplements so that the animal may receive at all times an adequate diet. In the light of present knowledge we can no longer look upon numbers of animals in a given area as an index of wealth, but rather the number that can be most efficiently handled under the feed supply available in the respective areas.

Improvement in the quality of our range cattle, through the use of purebred, prepotent, and precocious sires, is sorely needed. Little can be gained by such a procedure, however, if such stock are to be limited by environmental factors, especially by a feed supply which prevents their desirable inherited qualities from developing. In England, livestock men have a common adage, "Half the breeding goes in by way of the mouth," which is very significant in our range situation. Without proper feed supply, our most highly bred animals must revert to scrubs or fail in the struggle for existence. In livestock production such a practice may be likened to placing a highly efficient machine on a task without giving it sufficient fuel.

Piper *et al.*,[2] in a comprehensive report on our national forage resources, have discussed the importance of doing more extensive research work on pastures. They showed that 55 per cent of the total land area in the United States is used for grazing even if crop land pastured part of the year is excluded. Certain studies included showed that gains made by cattle on pasture cost, in general, only one-half to one-fourth as much as those made when the animals were fed crops. The following significant statement is quoted from the paper:

Relegated largely to land too poor or too rough to till, neglected commonly by the farmer, often abused by the grazier, ignored by most investigators, our permanent pastures, both tame and wild, still furnish nearly four-tenths, and our rotation and temporary pastures over one-tenth, of all the feed consumed by domestic animals. Pasture is the key to profitable utilization of millions of acres of semi-waste land now lying idle or unproductive. "Better pastures" should be made the keynote in the promotion of American agricultural progress.

In the following pages are presented the information the authors have accumulated on chemical analyses of individual species and composite[6] samples of range forage at different stages of growth and seasons of the year. Data on the leaching effect of rain on dry forage are included. Results of digestion experiments with several species of forage plants have been published and are reviewed in this publication. Studies were made on the concentration of vitamin A in the livers of steers from the range. Also observations are given on certain problems connected with reproduction which are prevalent in livestock subsisting on natural forage and thought to be associated with nutrition.

METHODS OF PROCEDURE

Although some work had been done during 1927 and 1928 toward securing data on factors which influenced percentage calf crop in range herds, the broader aspects of this investigation did not get under way until July 1, 1929. At that time the project became cooperative with the United States Bureau of Animal Industry, and the financial aid thus secured made possible the appointment of a full-time helper to collect samples and one to carry on the laboratory analyses.

Area Covered by the Study.—About 50 per cent of the state's beef cattle population is located in the Sacramento and San Joaquin valleys and the foothills on either side. In this important production area, eighteen ranches extending from Tehama to Kern counties, and representative of large grazing tracts, were selected for this study. For the most part they were located in districts generally recognized as distinct areas from the standpoint of soil type and grazing value. The elevation varied from 100 to 1,200 feet.

Method of Taking Samples.—On each ranch a definite area was selected, as typical as possible with reference to soil and topography, and from it samples of the different forage species were collected at intervals throughout the season, except as otherwise noted. Small portions of each sample were taken over a fairly large tract, instead of limiting the area to small, definitely staked plots. In general, south slopes were se-

[6] The term "composite" is used where more than one species is included in the sample.

lected, because cattle show a preference for the forage on these exposures. The original plan was to collect 1 to 2-pound samples of the dry forage and a larger amount of green forage. This, however, was not always practical, since the collection of pure samples of single species was difficult and extremely time-consuming during the early vegetative stages and also on heavily grazed areas in the dry season or when a particular species was present in only meager amount. Under these circumstances, the amount of the sample was frequently limited to just sufficient for the analyses. In some cases even this quantity could not be obtained (although animals were subsisting on the area), and sampling had to cease. With the composite samples greater bulk was collected, because a larger quantity was necessary to be considered representative. Care was taken to obtain these samples from the forage that was actually being grazed, as indicated by observation of the cattle and the evidences of grazing.

Beginning with the early vegetative stage, a sample of each species was collected at monthly intervals until the rains had ceased and the forage had matured and dried. During the remainder of the year, samples of the dry feed were collected at longer intervals. Since many ranges vary from year to year in botanical composition, presumably because of rainfall and temperature conditions, two series of samples were collected. One series represented, as nearly as possible, the forage actually being grazed at the time of collection, while the other included pure samples of the six principal species under study.

The stage of growth, the principal species (if a composite sample), and the weight of the sample were recorded at the time of collection.

Chemical Analysis.—Analyses were made of the forage samples to determine moisture, total ash, acid-insoluble ash, crude protein, crude fiber, alkalinity, calcium, and phosphorus. In a few cases the ether extract was determined. The official methods as outlined in the *Methods of Analysis of the Association of Official Agricultural Chemists,* 2nd edition, were used for moisture, total ash, crude protein, crude fiber, calcium, and ether extract. The acid-insoluble residue was determined by the method for sand and silica given on page 39, paragraph 2. The silica-free ash in the tables of analyses is the difference between the total ash and the acid-insoluble ash.

In determining alkalinity, the ash was warmed with an excess of N/10 HCl and filtered, and the excess acid was titrated with N/10 NaOH, methyl orange being used as an indicator. The alkalinity is expressed as the number of cubic centimeters of N/10 HCl required per 100 grams of sample.

The official method for phosphorus determination, as outlined on page 3 of official methods, gives satisfactory results when the aliquot used contains from 10 to 20 mg of phosphorus. In many samples analyzed, the phosphorus content varied between 30 and 250 mg per 100 grams of sample. To obtain a suitable aliquot, therefore, as much as 50 grams would have to be ashed for a single determination.

Phosphorus was therefore ascertained colorimetrically by an application of the Fiske and Subbarow[3] method. The determination was carried out in the usual manner on the hydrochloric acid solution of the ashed material obtained at a low temperature in an electric muffle. This method, so applied, has given excellent results in this laboratory when tested against 35 parallel determinations made by the volumetric method. The maximum deviation in the results obtained was 3.7 per cent; the average deviation, slightly over 1 per cent.

The colorimetric method is simple and rapid. After the samples have been ashed and brought into solution, thirty or more determinations may be made in a single morning. Since only 0.4 mg of phosphorus is required in each determination, much less of the original sample need be ashed. As this method saved much time without sacrificing accuracy, it was adopted and used throughout this investigation.

PLANT SPECIES ON WHICH ANALYSES WERE MADE AT VARIOUS STAGES OF GROWTH

Samples of six important forage species were collected at various stages of growth and after maturity. The species included were bur clover (*Medicago hispida*), representing the most important legume; three species of alfilaria (*Erodium* sp.), representing the most common herbaceous plants; and wild oats (*Avena* sp.[7]), together with what is variously termed soft chess, brome grass, or soft cheat (*Bromus hordeaceus*), as important representatives of the grass species. Bur clover is widely distributed throughout the state, growing particularly on the heavier loam and adobe soils. The three species of alfilaria analyzed are commonly known as broadleaf or buck alfilaria (*E. botrys*), red stem or fern alfilaria (*E. cicutarium*), and white stem or silver alfilaria (*E. moschatum*). The broadleaf species grows in greatest abundance in most sections. The red stem alfilaria predominates in the southwestern and southern areas of the San Joaquin Valley, and on some ranges constitutes the greater portion of the forage. The white stem, although relished by livestock is found in small amounts in restricted localities and in the area studied does not constitute so important a species as the other two. It is, however, very common and abundant near the coast.

[7] Many samples probably contained both *A. fatua* and *A. barbata*.

Wild oats are widely distributed throughout California and are an important grass species on winter and spring ranges. Soft chess, also widely distributed, is the most important of the annual brome grasses from the standpoint of grazing value. Both species are poor forage after maturity.

RANCHES FROM WHICH SAMPLES WERE COLLECTED

To facilitate discussion, the sampling areas included in this study were arbitrarily grouped into southern, central, and northern ranches. The nine southern ranches include those in the San Joaquin Valley extending from the Kern County line to Oakdale; the five central ranches were in the vicinities of Ione, Folsom, and Marysville; and the four northern ranches were located in the vicinity of Red Bluff. For description of the ranches from which the samples were taken see appendix.

DATA ON ANALYSES OF SAMPLES

Table 1 lists for study the analyses of the samples collected on each one of the eighteen ranches throughout 1930 and on six of the eighteen during 1931. This rather large amount of data is given in this way because of the meager information available, in published reports, on the chemical composition of these forage species at various seasons of the year when grown under natural conditions accompanied with grazing. In attempting to apply this information on individual ranches it will be desirable to select the analyses of plants grown in the nearest locality and from comparable soil types. It was not practicable to collect complete series of all species from the different ranches. On some ranches certain species were not present or were so limited in quantity as to render collection of pure species samples extremely difficult. In some cases the forage was depleted by grazing in the green stages so that no dry samples were obtainable. Likewise, pure samples at very early stages were limited by difficulty in sampling, and a month later the plants had reached an advanced stage of development. There is a rather wide range in the stages indicated, such as early green, bloom, dry, etc., because of the great difficulty in obtaining a number of samples at comparable stages of growth over such a wide area as was originally included in this study. The desired end was more nearly accomplished in 1931, when sample collecting was limited to six of the original eighteen ranches. In order that the reader may see the differences between the various species of forage plants more readily than are shown by the data in table 1, we have presented in figure 1, averages of the samples of individual species at various growth stages, collected in 1930 and 1931, respectively.

TABLE 1

PERCENTAGE COMPOSITION OF RANGE FORAGE AT DIFFERENT SEASONS; 1930 AND 1931*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
				Ranch No. 1						
White stem alfilaria	318	Early green	2/23/31	28.14	46.74	11.24	13.88	1.94	0.46	4.2
	347	Bloom	3/13/31	22.25	52.57	12.54	12.64	2.07	0.42	4.9
	380	Wilting‡	4/ 8/31	16.70	51.17	17.64	14.49	2.66	0.35	7.6
Red stem alfilaria	319*	Early green	2/23/31	26.52	48.99	12.18	12.31	1.72	0.46	3.7
	346*	Bloom	3/13/31	21.10	53.81	12.79	12.30	1.80	0.47	3.8
	381*	Wilting	4/ 8/31	14.86	52.76	18.73	13.65	2.20	0.34	6.5
Broadleaf alfilaria	73*	Green	3/11/30	24.50	57.29	11.93	6.28	1.43	0.38	3.7
	130*	Wilting	4/17/30	9.87	51.97	28.70	9.46	1.64	0.26	6.3
	300*	Dry, leached	11/21/30	4.79	58.51	33.42	3.28	1.62	0.07	23.1
	316*	Early green	2/19/31	19.35	59.65	10.80	10.20	1.39	0.35	4.0
	345*	Bloom	3/13/31	18.31	59.64	12.40	9.65	1.43	0.36	4.0
	383*	Drying	4/ 8/31	11.16	56.07	23.50	9.27	1.42	0.36	3.9
	412*	Dry, leached	5/11/31	7.09	58.95	25.01	8.95	1.89	0.17	11.1
	448*	Dry, leached	6/10/31	6.47	62.67	24.90	5.96	2.15	0.13	16.5
	483*	Dry, leached, new area	7/ 9/31	7.93	60.65	26.58	4.84	1.84	0.08	23.0
	494*	Dry, leached, new area	8/16/31	7 83	60 62	25.40	6.15	1.86	0.09	20.6
	527*	Dry, leached, new area	10/15/31	8.19	62.61	24.30	4 90	1.88	0.08	23.5
Bur clover	71*	Green	3/11/30	29.22	48 92	12.96	8.90	0.86	0.44	1.9
	128*	Wilting	4/17/30	21.71	46.18	24.88	7.23	1.09	0.30	3.6
	178*	Nearly dry	5/11/30	18.30	47.03	27.86	6.81	1.33	0.25	5.3
	215*	Dry	6/ 9/30	15.02	43.19	33.37	6.51	1.26	0.25	5.0
	297*	Dry, leached	11/21/30	16.55	46.70	32.59	4.16	1.11	0.26	4.2
	344*	Early green	3/13/31	29.15	48.82	13.81	8.22	1.09	0.39	2.8
	384*	Wilting	4/ 8/31	24.71	47.61	20.33	7.35	1.24	0.31	4.0
	413*	Dry, leached	5/10/31	22.69	48.71	22.81	5.79	1.14	0.26	4.4

Soft chess	131*	Green, headed	4/17/30	11.68	52 85	31.58	3.89	0.28	0.36	0.7
	177*	Drying	5/11/30	10.87	61.80	24.19	3.14	0 24	0.30	0.8
	298*	Dry, leached	11/21/30	7.80	51.70	39.29	1.21	0.39	0 06	6.5
	378*	Green, headed	4/ 8/31	14.03	58.45	23.78	3.74	0.27	0.36	0.7
	414*	Dry, leached	5/10/31	10.73	62 18	23.37	3.72	0.35	0.29	1.2
	449*	Dry, leached	6/10/31	6.34	61.69	30.58	1.39	0.24	0.13	1.8
	481	Dry, leached, new area	7/ 9/31	4.57	.....	29.42	.....	.....	0.06	.....
	495*	Dry, leached, new area	8/16/31	5 70	61 93	30.33	2.04	0.31	0.07	4.4
	526*	Dry, leached, new area	10/15/31	5.88	60 94	31.00	2.18	0.44	0.09	4.9
Wild oats	129*	Green, headed	4/17/30	11 21	52 11	33.48	3.20	0.17	0.30	0.5
	176	Wilting	5/11/30	9.05	60.19	26.97	3.79	0.22	0.28	0.8
	217*	Dry	6/ 9/30	6.01	58 69	32.03	3.27	0.29	0.19	1.5
	299*	Dry, leached	11/21/30	2.42	58.49	37.87	1.22	0.30	0.06	5.0
	379*	Green, headed	4/ 8/31	10.57	57.15	29.37	2.91	0.21	0.24	0.8
	411*	Dry, leached	5/10/31	5.57	58.87	31.41	4.15	0.25	0.16	1.5
	450*	Dry, leached	6/10/31	3.75	56.80	38.10	1.35	0.14	0.13	1.0
	482	Dry, leached, new area	7/ 9/31	.....	.....	33.72	2.74	0.15	0.08	1.8
	496*	Dry, leached, new area	8/16/31	3.65	60.80	33.12	2.43	0.12	0.06	2.0
	525*	Dry, leached, new area	10/15/31	4.05	60.58	33.80	1.57	0.19	0.08	2.3
Composite sample	51	Green	2/ 4/30	31.23	41 01	18.31	9.45	0.73	0.52	1.4
	72	Green	3/11/30	23.30	50.12	19.28	7.30	0.51	0.47	1.1
	216	Dry, alfilaria predominant	6/ 9/30	8.14	58.26	27.98	5.62	1.84	0.18	10.2
	267	Dry, bur clover predominant	8/21/30	14.72	52.37	27.14	5.77	1.27	0.26	5.0
	317	Green, alfilaria predominant	2/19/31	27.60	51.47	11.40	9.53	1.26	0.45	2.8
	348	Green, alfilaria predominant	3/13/31	27.24	50 32	12.46	9.98	1.25	0.46	2.7
	382	Wilting, bur clover predominant	4/ 8/31	19.76	54 02	18.80	7.42	1.17	0.36	3.3
	415	Dry, bur clover predominant, leached	5/11/31	12 30	56.27	24.66	6.77	1.37	0.24	5.7
	447	Dry, leached, alfilaria predominant	6/10/31	7.26	59.62	28.43	4.69	1.90	0.13	14.6
	484	Dry, leached, new area	7/ 9/31	7.34	58.24	30.82	3.60	1.49	0.08	18.6
	497	Dry, leached, new area	8/16/31	8 17	56.05	31.20	4.58	1.39	0.09	15.4
	528	Dry, leached, new area	10/15/31	8.23	58 00	30.20	3.57	1.34	0.10	13.4

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Continued*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
Ranch No. 2										
Red stem alfilaria	121*	Bloom	4/12/30	15.75	49.21	23.65	11.39	1.75	0.54	3.2
	173*	Wilting‡	5/10/30	13.79	55.57	20.00	10.64	2.08	0.41	5.1
	120*	Wilting	4/12/30	10.84	49.23	32.31	7.72	1.25	0.42	2.9
Broadleaf alfilaria	172*	Nearly dry	5/10/30	5.96	58.52	27.36	8.16	1.68	0.14	12.0
	219*	Dry	6/ 9/30	5.24	60.38	28.00	6.38	1.85	0.14	13.2
	296*	Dry, leached	11/20/30	3.17	56.50	37.10	3.23	1.28	0.05	25.6
Bur clover	118*	Bloom	4/12/30	21.23	47.25	22.39	9.13	1.57	0.47	3.3
	174*	Wilting	5/10/30	14.90	46.28	31.61	7.21	1.60	0.27	5.9
	119*	Heading	4/12/30	8.71	52.35	35.16	3.78	0.21	0.33	0.6
Wild oats	175	Wilting	5/10/30	6.82	58.07	31.96	3.15	0.27	0.30	0.9
	218*	Dry	6/ 9/30	3.21	61.05	32.47	3.27	0.31	0.27	1.2
	295*	Dry, leached	11/20/30	1.81	60.81	36.66	0.72	0.15	0.06	2.5
Composite sample	52	Green, with old	2/ 4/30	12.89	55.28	26.00	5.83	0.95	0.25	3.8
	74	Green, some old	3/11/30	15.55	56.06	21.36	7.03	0.91	0.38	2.4
	220	Dry, bur clover predominant	6/ 9/30	11.06	50.00	33.10	5.84	1.51	0.27	5.6
	266	Dry, bur clover predominant	8/21/30	9.96	53.95	29.49	6.60	1.33	0.26	5.1
Ranch No. 3										
White stem alfilaria	113	Bloom	4/11/30	22.72	44.65	18.05	14.58	2.51	0.57	4.4
	308	Early green	2/17/31	37.95	36.41	11.01	14.63	1.82	0.50	3.6
	331	Bloom	3/10/31	29.70	44.22	12.08	14.00	2.05	0.48	4.3
	336	Heading	3/11/31	22.96	51.72	12.51	12.81	2.15	0.46	4.7
	355	Wilting	4/ 6/31	22.30	43.96	18.24	15.50	2.84	0.43	6.6
	363	Green, seed stage	4/ 6/31	17.78	51.65	16.89	13.68	2.90	0.44	6.6
Red stem alfilaria	112*	Bloom	4/11/30	15.57	49.82	23.37	11.24	2.02	0.47	4.3
	307*	Early green	2/17/31	34.21	40.04	10.56	15.09	2.55	0.47	5.4
	330*	Heading	3/10/31	28.83	47.00	11.75	12.42	1.83	0.31	5.9
	356*	Wilting	4/ 6/31	17.76	50.97	18.34	13.03	2.64	0.27	9.8

Broadleaf alfilaria	54*	Early green	2/ 5/30	27.93	46.43	14.85	10.79	1.81	0.40	4.5
	111*	Bloom	4/11/30	10.30	51.18	30.93	7.59	1.17	0.38	3.1
	309*	Early green	2/17/31	36.06	39.22	11.00	13.72	1.59	0.46	3.5
	333*	Early heading, adobe	3/11/31	25.22	50.99	12.57	11.22	1.84	0.31	5.9
	337*	Headed, bloom, loam	3/11/31	18.48	59.18	13.56	8.78	1.51	0.30	5.0
	358*	Wilting, adobe	4/ 6/31	16.74	53.39	20.83	9.04	1.39	0.31	4.5
	362*	Wilting, loam	4/ 6/31	12.30	56.00	22.48	9.22	1.31	0.24	5.5
Bur clover	110*	Bloom	4/11/30	24.58	45.31	21.41	8.70	1.34	0.44	3.0
	160*	Nearly dry	5/ 8/30	15.45	48.29	29.89	6.37	1.17	0.24	4.9
	226*	Dry	6/10/30	18.23	50.43	25.71	5.63	1.20	0.30	4.0
	306*	Early green	2/17/31	36.10	40.36	11.70	11.84	1.07	0.47	2.3
	332*	Early green	3/11/31	33.31	44.91	12.87	8.91	1.26	0.38	3.3
	359*	Wilting	4/ 6/31	24 25	46.49	22.25	7.01	1.17	0.34	3.4
	360*	Wilting, adobe	4/ 6/31	25.42	45.55	21.50	7 52	1.13	0.38	3.0
	398*	Dry, leached	5/ 8/31	17.12	52.96	20.67	9.25	2.02	0.22	9.2
	430*	Dry, leached	6/ 8/31	18.32	52.51	22.80	6.37	1.75	0.19	9.2
Soft chess	357*	Wilting, adobe	4/ 6/31	11.70	61.77	22.44	4.09	0.47	0.34	1.4
	361*	Wilting, loam	4/ 6/31	13.03	59.96	22.41	4.60	0.37	0.39	0.8
	393*	Dry, leached, loam	5/ 8/31	8 44	61.05	26.92	3.59	0.37	0.20	1.9
	396*	Dry, leached, adobe	5/ 8/31	10.95	58.96	25.15	4.94	0.71	0.23	3.1
	428*	Dry, leached, loam	6/ 8/31	7.40	63.80	26.56	2.24	0.36	0.16	2.2
	432*	Dry, leached, adobe	6/ 8/31	8.69	60.29	27.45	3.57	0.70	0.14	5.0
	472*	Dry, leached, loam	7/ 9/31	6.89	63.75	26.97	2.39	0.43	0.13	3.3
	475*	Dry, leached, adobe	7/ 9/31	8.40	60.96	24.50	6.14	0.81	0.14	5.8
	503*	Dry, leached, adobe	8/17/31	5.77	64.38	26.44	2.41	0.49	0.11	4.4
Wild oats	354*	Headed	4/ 6/31	8.87	59.66	27.25	4.22	0.31	0.26	1.2
	395*	Dry, leached	5/ 8/31	4.84	55.65	33.85	5.66	0.34	0.21	1.6
	431*	Dry, leached	6/ 8/31	5.22	59.27	32.62	2.89	0.33	0.17	2.0
	476*	Dry, leached	7/ 9/31	5.42	60.42	31 00	3.16	0.30	0 15	2.0
	502*	Dry, leached	8/17/31	4.98	62.80	29.55	2.67	0.27	0.11	2.4

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Continued*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
				Ranch No. 3—*Continued*						
Composite sample	76	Early green, alfilaria predominant	3/12/30	22.10	53.14	14.68	10.08	1.53	0.54	2.8
	163	Dry, alfilaria predominant	5/ 9/30	9.63	52.65	28.64	9.08	2.52	0.19	13.3
	225	Dry, alfilaria predominant	6/10/30	8.45	57.82	25.55	8.18	2.54	0.21	12.1
	263	Dry, alfilaria predominant	8/20/30	5.96	58.51	28.92	6.61	1.61	0.09	17.9
	289	Dry, leached, alfilaria predominant	11/19/30	5.47	56.28	35.04	3.21	1.48	0.06	24.7
	290	Dry, leached, bur clover predominant	11/19/30	15.60	49.55	29.77	5.08	1.54	0.22	7.0
	310	Early green, adobe, alfilaria predominant	2/17/31	34.49	43.02	10.36	12.13	1.49	0.51	2.9
	311	Early green, loam, alfilaria predominant	2/17/31	29.00	47.20	11.74	12.06	1.52	0.68	2.2
	334	Early green, adobe, alfilaria predominant	3/11/31	30.26	45.23	13.18	11.33	1.63	0.50	3.3
	335	Green, alfilaria predominant, loam	3/11/31	28.86	45.52	13.29	12.33	1.74	0.59	2.9
	351	Dry, alfilaria predominant, loam	4/ 6/31	9.96	60.31	22.90	6.83	0.94	0.35	2.7
	352	Dry, alfilaria predominant, adobe	4/ 6/31	9.09	60.98	21.89	8.04	1.21	0.33	3.8
	353	Dry, bur clover predominant, adobe	4/ 6/31	18.75	55.04	16.86	9.35	1.69	0.29	5 8
	364	Wilting,‡ alfilaria predominant	4/ 6/31	18.62	52.00	19.08	10.30	1.88	0.42	4.5
	394	Dry, leached, alfilaria predominant, loam	5/ 8/31	9.26	56.63	24.11	10.00	2.50	0.21	11.9
	397	Dry, leached, adobe, bur clover predominant	5/ 8/31	16.13	52.43	22.51	8.93	1.75	0.22	8.0
	429	Dry, leached, alfilaria predominant	6/ 8/31	7.76	59.28	25.90	7.06	2.17	0.14	15.5
	433	Dry, leached, bur clover predominant, adobe	6/ 8/31	14.86	51.77	27.44	5.93	1.81	0.17	10.6
	471	Dry, leached, grass, alfilaria, loam	7/ 9/31	8.30	60.08	27.52	4.10	1.69	0.13	13.0
	477	Dry, leached, adobe, bur clover predominant	7/ 9/31	12.27	54.65	23.85	9.23	2.20	0.16	13.7
	501	Dry, leached, adobe, some bur clover	8/17/31	10.70	58.77	25.21	5.32	1.80	0.14	12.8
	506	Dry, leached, grass, alfilaria, loam	8/17/31	8.30	60.96	26.12	4.62	1.87	0.13	14.4
	533	Dry, leached, grass, alfilaria, loam	10/16/31	7.10	62.90	25.60	4.40	1.77	0.13	13.6
	534	Dry, leached, adobe, some bur clover	10/16/31	11.32	57.93	24.45	6.30	2.19	0.15	14.6

Ranch No. 4

Red stem alfilaria	114*	Bloom	4/11/30	22.46	44.28	21.05	12.21	2.11	0.52	4.1
	169*	Wilting	5/10/30	16.85	49.36	24.04	9.75	2.31	0.42	5.5
	115*	Headed	4/11/30	12.39	51.07	27.52	9.02	1.35	0.27	5.0
Broadleaf alfilaria	223*	Dry	6/10/30	4 87	59.78	28.00	7.35	1.75	0.09	19.4
	314*	Early green	2/18/31	23.26	53.90	11.30	11.54	1.76	0.40	4.4
	341*	Headed	3/12/31	16.92	61.75	12.90	8.43	1.50	0.30	5.0
	377*	Wilting	4/ 7/31	12.83	52.34	26.07	8.76	1.44	0.22	6.5
Bur clover	116*	Bloom	4/11/30	22.96	48.56	19.36	9.12	1.36	0.30	4.5
	168*	Wilting	5/10/30	16.41	46.94	31.27	5.38	1.43	0.16	8.9
	224*	Dry	6/10/30	14.62	45.72	34.15	5.51	1.19	0.16	7.4
	375*	Green, seed	4/ 7/31	23.61	47.56	21.16	7.67	1.30	0.25	5.2
	408*	Dry, leached	5/ 9/31	17.77	49.98	26.23	6.02	1.15	0.19	6.1
Soft chess	171A	Green stems	5/10/30	5.02	55.31	36.88	2.79	0.17	0.21	0.8
	171B	Green heads	5/10/30	12.12	60.89	23.81	3.18	0 28	0.38	0.7
	221*	Dry	6/10/30	6.78	57.68	31.54	4.00	0 24	0.25	1.0
	373*	Green, headed	4/ 7/31	12.66	58.06	25.07	4.21	0.29	0.36	0.8
	407*	Dry, leached	5/ 9/31	9.65	60.66	26.35	3.34	0.29	0.28	1.0
	446*	Dry, leached	6/ 9/31	6.20	56.92	35.41	1.47	0.36	0.09	4.0
	479*	Dry, leached	7/ 9/31	6.13	59.35	33.55	2.08	0.43	0.09	4.8
	498*	Dry, leached	8/16/31	6.43	61.23	30.30	2.04	0.41	0.10	4.1
	537*	Dry, leached	10/16/31	5.36	61.95	30.80	1.89	0.53	0.08	6.6
Wild oats	117*	Bloom	4/11/30	12.63	53.25	28.03	6.09	0.28	0.36	0.8
	170	Seed	5/10/30	6.81	57.47	33.12	2.60	0.18	0.22	0.8
	222*	Dry	6/10/30	4.56	61.77	30.05	3.62	0.29	0.13	2.2
	265*	Dry	8/21/30	2.78	62.64	30.73	3.85	0.23	0.08	3.0
	293*	Dry, leached	11/20/30	1.66	59.96	37.65	0.73	0.16	0.03	5.3
	342*	Early green	3/12/31	15.90	56.63	20.49	6.98	0.45	0.35	1.3
	374*	Bloom	4/ 7/31	9.62	57 56	29.30	3.52	0.21	0.25	0.8
	409*	Dry, leached	5/ 9/31	5.00	56.55	34.60	3.85	0.31	0.17	1.8
	444*	Dry, leached	6/ 9/31	3.58	60.54	35.20	0.68	0.10	0.08	1.2
	478*	Dry, leached	7/ 9/31	3.14	58.41	36 20	2.25	0.23	0.10	2.3
	499*	Dry, leached	8/16/31	3.55	60.37	34.00	2.08	0.23	0.11	2.0
	536*	Dry, leached	10/16/31	3.16	60.23	35.10	1.51	0.18	0.07	2.5

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Continued*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
				Ranch No. 4—*Continued*						
Composite sample	75	Early green	3/12/30	17.61	51.76	19.25	11.38	1.03	0.30	3.4
	264	Dry, bur clover predominant	8/21/30	10.15	53.83	30.46	5.56	1.19	0.12	9.9
	294	Dry, leached, some bur clover	11/20/30	8 04	52.73	35.16	4.07	1.28	0.09	14.2
	315	Early green, with old	2/18/31	17 46	48.79	26.44	7.31	0.92	0.28	3.3
	343	Green	3/12/31	21 02	52.27	19.31	7.40	0.95	0.40	2.4
	376	Drying	4/ 7/31	15.05	52.00	24.26	6.88	0.74	0.30	2.5
	410	Dry, leached, bur clover predominant	5/ 9/31	11.11	56.83	26.67	5.39	0.90	0.17	5.3
	445	Dry, leached, alfilaria predominant	6/ 9/31	6.38	58.73	32.20	2.69	1.12	0.07	16.0
	480	Dry, leached, grass and alfilaria	7/ 9/31	.....	.....	31.57	3.39	0.96	0.10	9.6
	500	Dry, leached, grass and alfilaria	8/16/31	7.62	57.94	31.00	3.44	1.22	0.10	12.2
	538	Dry, leached, grass and alfilaria	10/16/31	7.82	57.48	31.60	3.10	1.08	0.10	10.8
				Ranch No. 5						
Broadleaf alfilaria	55*	Early green	2/ 6/30	24.22	49.24	16.43	10.11	1.60	0.40	4.0
	104*	Bloom	4/10/30	10.87	50.32	32.83	5.98	0.99	0.24	4.0
	157*	Dry	5/ 8/30	4.59	55.16	32.93	7.32	1.74	0.05	34.8
	231*	Dry	6/ 2/30	5.50	57.73	28.13	8.64	1.71	0.06	28.5
	260*	Dry	8/19/30	4.62	56.70	30.18	8.50	1.79	0.05	35.8
	288*	Dry, leached	11/18/30	4.70	54.21	36.15	4.94	2.04	0.06	34.0
	304*	Early green	2/16/31	29.33	46.35	11.02	13.30	1.77	0.38	4.6
	328*	Bloom	3/10/31	11.50	61.62	17.24	9.54	1.85	0.33	5.6
	372*	Dry	4/ 7/31	12.65	56.94	21.40	9.01	1.20	0.18	6.7
	404*	Dry, leached	5/ 9/31	11.58	52.51	27.22	8.69	1.38	0.09	15.3
	441*	Dry, leached	6/ 9/31	5.89	55.59	31.30	7.22	1.68	0.06	28.0
	465*	Dry, leached	7/ 8/31	5.92	59.27	27.80	7.01	2.11	0.09	23.4
	515*	Dry, leached	8/19/31	6.27	62.57	26.03	5.13	2.07	0.09	23.0
	530*	Dry, leached	10/16/31	6.02	63.97	24.90	5.11	2.14	0.09	23.8

Wild oats	103*	Heading	4/10/30	7.99	55.04	33.13	3.84	0.21	0.24	0.9
	156	Drying	5/ 8/30	5.25	54.36	38.16	2.23	0.20	0.16	1.2
	230*	Dry	6/12/30	3.29	56.46	35.71	4.54	0.19	0.18	1.0
	326*	Early green	3/10/31	12.58	58.25	23.41	5.76	0.38	0.42	0.9
	370	Drying	4/ 7/31	8.47	58.57	29.69	3.27	0.24	0.24	1.0
	405*	Dry, leached	5/ 9/31	3.18	58.70	33.20	4.92	0.31	0.18	1.7
	440*	Dry, leached	6/ 9/31	2.35	57.75	37.42	2.48	0.27	0.09	3.0
	464*	Dry, leached	7/ 8/31	3.34	61.80	32.80	2.06	0.29	0.10	2.9
	512*	Dry, leached	8/19/31	2.70	61.72	33.92	1.66	0.20	0.09	2.2
Composite sample	78	Green, alfilaria predominant	3/13/30	16.66	58.33	16.61	8.40	1.33	0.42	3.1
	327	Green, unheaded, alfilaria predominant	3/10/31	18.95	56.17	17.04	7.84	1.16	0.36	3.2
	371	Wilting,‡ alfilaria predominant	4/ 7/31	9.05	58.67	24.88	7.40	1.10	0.26	4.2
	406	Dry, leached, alfilaria predominant	5/ 9/31	6.48	58.69	27.50	7.33	1.35	0.12	11.3
	443	Dry, leached, alfilaria predominant	6/ 9/31	5.47	56.70	32.96	4.87	1.62	0.08	20.0
	466	Dry, leached, alfilaria predominant	7/ 8/31	6.01	58.79	29.50	5.70	1.64	0.10	16.4
	513	Dry, leached, alfilaria predominant	8/19/31	6.28	62.15	27.40	4.17	1.66	0.08	20.7
	531	Dry, leached, alfilaria predominant	10/10/31	5.89	63.71	24.90	5.50	1.89	0.09	21.0
		Ranch No. 6								
Red stem alfilaria	167*	Wilting	5/ 9/30	12.48	56.99	22.36	8.17	2.05	0.29	7.0
	338*	Bloom	3/12/31	24.15	48.94	14.12	12.79	2.51	0.47	5.3
	366*	Bloom	4/ 7/31	14.28	53.11	19.35	13.26	2.67	0.42	6.4
	402*	Wilting	5/ 9/31	8.58	56.19	23.28	11.95	2.81	0.29	9.7
	438*	Green, second growth	6/ 9/31	12.14	59.35	16.65	11.86	2.78	0.34	8.2
	439	Dry, leached	6/ 9/31	5.59	57.96	30.05	6.40	2.71	0.13	20.8
	470	Dry, leached	7/ 9/31	5.48	59.84	28.18	6.50	2.54	0.15	17.0
Broadleaf alfilaria (*Continued on next page*)	109*	Bloom	4/10/30	10.36	52.72	30.75	6.17	1.05	0.34	3.1
	164*	Dry	5/ 9/30	5.83	56.20	29.78	8.19	1.73	0.11	15.7
	228*	Dry	6/11/30	5.24	54.91	28.72	8.31	1.81	0.08	22.6
	261*	Dry	8/20/30	5.09	57.99	28.99	7.93	1.80	0.08	22.5
	291*	Dry, leached	11/19/30	3.11	59.30	35.24	2.35	1.17	0.03	39.0

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Continued*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
				Ranch No. 6—*Continued*						
Broadleaf alfilaria (*Concluded*)	313*	Early green	2/18/31	16.39	60.93	11.09	11.59	2.10	0.31	6.8
	339*	Bloom	3/12/31	13.73	61.08	17.08	8.11	1.74	0.32	5.4
	367*	Wilting‡	4/ 7/31	9.91	53.87	28.67	7.55	1.29	0.33	3.9
	400*	Dry, leached	5/ 9/31	4.31	55.70	30.31	9.68	1.80	0.09	20.0
	435*	Dry, leached	6/ 9/31	3.63	56.36	32.45	7.56	2.08	0.07	29.7
	469*	Dry, leached	7/ 9/31	3.82	57 89	29.70	8.59	2.22	0.11	22.0
	508*	Dry, leached	8/18/31	3.55	61.96	29.50	4.99	1.94	0.08	24.2
Soft chess	166*	Headed	5/ 9/30	10.52	61.15	25.07	3.26	0.30	0.33	0.9
	229*	Dry	6/11/30	7.30	63.34	26.53	2.83	0 37	0.27	1.4
	368*	Headed	4/ 7/31	13.75	54.62	27.33	4.30	0.35	0.41	0.9
	401*	Dry, leached	5/ 9/31	10.39	61.76	23.79	4.06	0.38	0.37	1.0
	437*	Dry, leached	6/ 9/31	4.54	58.82	34.36	2.28	0.32	0.12	2.6
	467*	Dry, leached	7/ 9/31	5.16	60.71	32.20	1.93	0.31	0.12	2.6
	511*	Dry, leached	8/18/31	3.79	58.99	35.20	2.02	0.40	0.08	6.2
Composite sample	53	Green, grass and alfilaria	2/ 5/30	22.34	48.84	19.18	9.64	1.22	0.42	2.9
	77	Green, grass and alfilaria	3/13/30	20.06	49.19	22.13	8.62	1.19	0.53	2.2
	108	Green, grass only	4/10/30	17.53	42.60	31.36	8.51	0.51	0.50	1.0
	165	Dry, alfilaria predominant	5/ 9/30	7.24	57.07	28.66	7.03	1.40	0.15	9.3
	227	Dry, alfilaria predominant	6/11/30	5.23	58.55	29.59	6.63	1.65	0.15	11.0
	262	Dry, alfilaria predominant	8/20/30	4.59	59.90	28.49	7.02	1.52	0.09	17.0
	292	Dry, leached, grass predominant	11/19/30	2.61	59.30	36.59	1.50	0.71	0.05	14.0
	312	Early green, alfilaria predominant	2/18/31	25.04	48.46	17.02	9.48	1.47	0.28	5.3
	340	Green, alfilaria predominant	3/12/31	20.58	53.21	18.46	7.75	1.38	0.45	3.1
	365	Green, alfilaria predominant	4/ 7/31	16.36	51.41	23.90	8.33	1.37	0.43	3.2
	399	Dry, leached, alfilaria predominant	5/ 9/31	5.75	58.67	27.15	8.43	1.74	0.24	7.3
	434	Dry, leached, alfilaria predominant	6/ 9/31	5.74	57.44	30.66	6.16	2.02	0.10	20.2
	468	Dry, leached, alfilaria predominant	7/ 9/31	5.40	57.23	31.35	6.02	1.59	0.12	13.2
	509	Dry, leached, alfilaria predominant	8/18/31	4.59	57.55	34.20	2.66	1.46	0.07	20.8
	532	Dry, leached, grass predominant	10/16/31	4.76	60.21	32.40	2 63	0.87	0.07	12.4

Ranch No. 7										
Red stem alfilaria	96*	Wilting	4/ 8/30	20.59	48.30	17.38	13.73	3.08	0.42	7.3
	151*	Drying	5/ 5/30	18.10	53.36	16.12	12.42	3.35	0.30	11.2
	236*	Dry	6/14/30	8.51	55.60	22.77	13.12	3.02	0.18	16.7
Composite sample	58	Green	2/ 7/30	27.30	45.12	12.18	15.40	2.45	0.32	7.7
	95	Wilting, alfilaria predominant	4/ 8/30	16.38	49.68	19.18	14.76	2.81	0.24	11.7
	152	Dry, leached, alfilaria predominant	5/ 6/30	7.79	50.57	36.48	5.16	1.85	0.14	13.2
Ranch No. 8										
Composite sample	57	Green, alfilaria predominant	2/ 6/30	18.85	53.24	17.99	9.92	1.73	0.34	5.1
	102	Wilting, alfilaria predominant	4/ 9/30	15.43	52.47	24.24	7.86	1.65	0.32	5.2
Ranch No. 9										
Red stem alfilaria	98*	Wilting, bald slope	4/ 9/30	14.55	53.27	20.59	11.59	2.56	0.51	5.0
	101*	Wilting, wooded slope	4/ 9/30	26.06	42.22	15.55	16.17	2.95	0.61	4.8
	153*	Bloom, wooded slope	5/ 7/30	19.62	50.34	16.39	13.65	3.15	0.48	6.6
	234*	Wilted, wooded slope	6/13/30	12.95	48.39	27.34	11.32	3.13	0.45	7.0
Bur clover	97*	Wilting	4/ 9/30	23.87	49.64	16.97	9.52	1.53	0.44	3.5
Soft chess	100	Green	4/ 9/30	17.22	46.95	28.58	7.25	0.58	0.46	1.3
	154*	Dry, leached	5/ 7/30	10.83	54.67	31.15	3.35	0.47	0.29	1.6
Wild oats	155*	Drying, leached	5/ 7/30	7.17	54.34	34.71	3.78	0.19	0.16	1.3
	235*	Dry	6/13/30	6.98	54.48	33.39	5.15	0 43	0.28	1.5
Composite sample	56	Green	2/ 6/30	20.98	50.80	18.89	9.33	1.40	0.37	3.8
	79	Green, grass and alfilaria	3/14/30	19.63	53.83	16.98	9.56	1.67	0.53	3.2
	99	Wilting, grass predominant	4/ 9/30	13.99	54.70	24.19	7.12	1.14	0.32	3.6

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Continued*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
Ranch No. 10										
White stem alfilaria	147	Green, wilting‡	5/ 3/30	12.45	53.46	23.69	10.40	2.78	0.32	8.7
Red stem alfilaria	148*	Green, wilting	5/ 3/30	14.78	53 16	21.81	10.25	2.91	0.31	9.4
Bur clover	92*	Bloom	4/ 3/30	23.66	50.91	17.90	7.53	2.33	0.33	7.1
	149*	Drying	5/ 3/30	17.19	46.98	29.22	6.61	2.64	0.26	10.2
	209*	Dry	6/ 5/30	18.37	43.89	32.05	5.69	1.72	0.34	5.1
Wild oats	150	Well headed	5/ 3/30	8.57	56 33	32.15	2.95	0.26	0.26	1.0
	208*	Dry	6/ 5/30	6.13	56.83	33.04	4.00	0.30	0.23	1.3
Composite sample	60	Green	2/27/30	22.83	47.70	17.43	12.04	1.77	0.49	3.6
	91	Bloom, alfilaria, broadleaf and white stem	4/ 3/30	17.58	56.80	14.64	10.98	2.02	0.36	5.6
	210	Dry, bur clover predominant	6/ 5/30	13.62	48.85	32.20	5.33	0.91	0.36	2.5
	258	Dry, bur clover predominant	8/14/30	16.05	48.74	30.19	5 02	1.21	0.39	3.1
	282	Dry, leached, some green	10/22/30	15.31	50.21	30.26	4.22	1.29	0.23	5.6
Ranch No. 11										
Broadleaf alfilaria	87*	Bloom	4/ 1/30	23.51	55.00	13.81	7.68	1.50	0.35	4.3
	144*	Wilting	5/ 2/30	7.02	60.27	26.27	6.44	1.31	0.35	3.7
	206*	Dry	6/ 4/30	4.29	56.93	32.07	6.71	1.49	0.10	14.9
Bur clover	86*	Bloom	4 /1/30	22.87	53.85	14.80	8.48	1.48	0.39	3.8
	141*	Drying	5/ 2/30	16.06	46.74	29.49	7.71	1.79	0.27	6.6
Wild oats	142	Headed	5/ 2/30	7.72	55.10	33.80	3.38	0.24	0.26	0.9
	207*	Dry	6/ 4/30	6.40	66.65	23.80	3.15	0.25	0.23	1.1
	281*	Dry, leached	10/21/30	1.87	60.59	36.89	0.65	0.19	0.06	3.1
Composite sample	62	Green	2/27/30	18.17	50.54	20.01	11.28	1.14	0.41	2.8
	143	Wilting	5/ 2/30	10.91	54.28	29.06	5.75	1.04	0.33	3.1
	205	Dry, bur clover predominant	6/ 4/30	10.77	50.51	33.73	4.99	1.12	0.21	5.3
	253	Dry, bur clover predominant	8/12/30	10.21	55.05	30.57	4.17	1.16	0.20	5.8
	280	Dry, leached	10/21/30	7.36	53.89	34.45	4.30	0.87	0.14	6.2

Ranch No. 12										
Bur clover	89*	Bloom	4/ 2/30	30.62	44.35	15.90	9.13	1.20	0.31	3.9
	213*	Dry	6/ 5/30	17.72	46.32	31.12	4.84	1.17	0.21	5.6
Wild oats	146	Partly headed	5/ 2/30	7.73	53.02	35.56	3.69	0.27	0.24	1.1
	214*	Partly dry	6/ 5/30	6.68	54.66	34.83	3.83	0.20	0.13	1.5
Composite sample	64	Early green and old dry	3/ 1/30	8.43	55.47	27.40	8.70	0.79	0.22	3.6
	88	Green, alfilaria predominant	4/ 2/30	23.63	49.93	19.73	6.71	1.11	0.24	4.6
	145	Wilting	5/ 2/30	12.92	55.66	25.63	5 79	1.07	0.26	4.1
	255	Dry, bur clover predominant	8/13/30	12.25	55.05	28.61	4.09	1.07	0.22	4.9
	279	Dry, leached, some green	10/21/30	10.36	54.28	30.87	4.49	0 95	0.15	6.3
Ranch No. 13										
Broadleaf alfilaria	84*	Headed	4/ 1/30	11.35	54.08	27.61	6.96	1.02	0.46	2.2
Soft chess	211*	Dry	6/ 5/30	9.37	62.11	25.95	2.57	0.25	0.29	0.9
	284*	Dry, leached	10/22/30	4.07	61.43	33.78	0.72	0.20	0.08	2.5
Composite sample	63	Early green, alfilaria predominant	2/28/30	18.93	55.82	13.61	11.64	1.41	0.40	3.5
	90	Green, grass predominant	4/ 2/30	17.42	57.26	16.98	8.34	0.69	0.50	1.4
	140	Wilting, alfilaria predominant	5/ 2/30	12.99	53.99	25.69	7.33	1.44	0.26	5.5
	212	Dry, alfilaria predominant	6/ 5/30	5.74	55.98	34.68	3.60	1.27	0.11	11.6
	254	Dry, alfilaria predominant	8/12/30	5.00	62.80	28.73	3.47	1.28	0.13	9.8
	283	Dry, leached, some green	10/22/30	8.80	54.38	33.68	3.14	0.86	0.22	3.9
Ranch No. 14										
Broadleaf	82*	Bloom	3/31/30	20.44	51.75	17.54	10.27	1.38	0 47	2.9
Bur clover	138*	Wilting	5/ 1/30	18.00	45.63	30.05	6.32	1.24	0.22	5.6
Soft chess	136*	Headed	5/ 1/30	12.70	51.80	31.90	3.60	0.23	0.35	0.7
	204*	Dry	6/ 3/30	8.23	61.17	27.21	3.39	0.25	0.25	1.0

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Continued*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
			Ranch No. 14—*Continued*							
Wild oats	137	Headed	5/ 1/30	8.27	49.88	38.24	3.61	0.19	0.25	0.8
	201*	Dry	6/ 3/30	5.17	57.72	34.30	2.81	0.23	0.14	1.6
Composite sample	49	Early green, old dry	1/28/30	15.38	52.02	27.70	4.90	0.92	0.32	2.9
	65	Green	3/ 1/30	20.67	52.47	20.25	6.61	1.04	0.35	3.0
	83	Green	3/31/30	20.55	51.79	19.92	7.74	1.27	0.47	2.7
	202	Dry, alfilaria predominant	6/ 3/30	6.99	58.78	28.45	5.78	1.33	0.12	11.1
	203	Dry, bur clover predominant	6/ 3/30	11.35	52.97	31.00	4.68	1.00	0.18	5.6
	252	Dry, bur clover predominant	8/11/30	8.63	61.14	25.72	4.51	0.93	0.18	5.2
	285	Dry, bur clover predominant	10/24/30	9.30	57.53	30.39	2.78	1.09	0.14	7.8
			Ranch No. 15							
Broadleaf alfilaria	80*	Headed	3/31/30	14.31	49.66	28.00	8.03	1.23	0.49	2.5
Bur clover	134*	Wilting‡	5/ 1/30	18.45	44.21	31.38	5.96	1.86	0.23	8.0
Soft chess	133*	Headed	5/ 1/30	12.86	54.36	29.20	3.58	0.30	0.37	0.8
	200*	Dry	6/ 3/30	9.43	62.13	25.70	2.74	0.36	0.27	1.3
Wild oats	135*	Headed	5/ 1/30	10.36	50.84	34.30	4.50	0.28	0.30	0.9
	199*	Dry	6/ 3/30	6.04	54.99	35.92	3.05	0.24	0.15	1.6
Composite sample	50	Green, some old	1/29/30	22.66	47.59	21.39	8.36	1.07	0.46	2.3
	66	Green, alfilaria and grass	3/ 2/30	18.14	53.25	18.69	9.92	1.18	0.38	3.1
	81	Green, grass predominant	3/31/30	17.02	48.81	26.78	7.39	0.64	0.56	1.1
	198	Dry, bur clover predominant	6/ 3/30	11.91	53.26	29.67	5.16	1.24	0.20	6.2
	251	Dry, bur clover predominant	8/11/30	10.21	59.23	26.19	4.37	1.27	0.18	7.0
	286	Dry, bur clover predominant	10/24/30	9.73	56.49	30.29	3.49	1.24	0.16	7.7

Ranch No. 16

Broadleaf alfilaria	122*	Wilting	4/16/30	10.66	51.87	31.49	5.98	0.97	0.37	2.6
	190*	Dry	5/14/30	5.14	61.61	27.89	5.36	1.42	0.07	20.0
	320*	Early green	2/24/31	26.59	52.75	10.71	9.95	1.53	0.47	3.3
	349*	Green	3/14/31	23.33	54.28	12.73	9.66	1.63	0.43	3.8
	386*	Bloom	4/ 8/31	12.37	56.21	24.19	7.23	1.28	0.40	3.2
	417*	Dry, leached	5/11/31	6.74	59.50	26.21	7.55	1.44	0.14	10.3
	452*	Dry, leached	6/10/31	5.64	58.83	30.60	4.93	2.16	0.07	31.0
	487*	Dry, leached	7/10/31	5.53	55.98	32.35	6.14	2.27	0.06	32.8
	517*	Dry, leached	8/19/31	7.48	56.22	31.30	5.00	2.11	0.08	26.3
	539*	Dry, leached	10/19/31	6.87	56.60	31.80	4.73	2.11	0.07	30.1
Bur clover	185*	Wilting	5/14/30	16.22	47.94	30.78	5.06	1.27	0.18	7.1
	237*	Dry	6/16/30	15.37	46.60	32.87	5.16	1.17	0.20	5.9
	385*	Bloom	4/ 8/31	23.50	54.03	15.65	6.82	1.38	0.22	6.3
	419	Drying	5/11/31	17.91	48.09	27.91	6.09	1.24	0.26	4.8
Soft chess	184*	Headed	5/14/30	11.60	63.44	22.66	2.30	0.35	0.31	1.1
	416*	Dry, leached	5/11/31	10.86	64.08	22.02	3.04	0.28	0.27	1.0
	451*	Dry, leached	6/10/31	3.42	55.99	39.50	1.09	0.31	0.06	5.1
	516*	Dry, leached	8/19/31	3.54	60.33	34.72	1.41	0.39	0.06	6.5
	541*	Dry, leached	10/19/31	4.46	62.92	31.20	1.42	0.39	0.06	6.5
Composite sample	59	Green, alfilaria predominant	2/13/30	22.39	52.62	15.57	9.42	1.12	0.38	3.0
	67	Green, alfilaria predominant	3/10/30	25.72	49.65	15.09	9.54	1.31	0.44	3.0
	123	Wilting, alfilaria predominant	4/16/30	13.91	54.25	26.12	5.72	1.03	0.35	2.9
	186	Wilting, bur clover predominant	5/14/30	14.11	54.25	26.55	5.09	1.37	0.22	6.2
	238	Dry, bur clover predominant	6/16/30	10.35	56.36	26.05	7.24	1.46	0.16	9.1
	268	Dry, bur clover predominant	8/22/30	9.68	54.99	28.92	6.41	1.44	0.12	12.0
	301	Dry, leached, grass and clover burs	11/24/30	9.38	51.23	35.66	3.73	1.24	0.11	11.1
	321	Early green, broadleaf alfilaria predominant	2/24/31	26.97	52.94	11.47	8.62	1.17	0.38	3.0
	350	Green, broadleaf alfilaria predominant	3/14/31	30.36	48.66	11.76	9.22	1.23	0.48	2.6
	387	Green	4/ 8/31	19.62	54.56	17.48	7.31	1.12	0.30	3.7
	418	Dry, leached, bur clover predominant	5/11/31	11.75	54.82	27.04	6.39	1.22	0.17	7.2
	453	Dry, leached, alfilaria predominant	6/10/31	6.23	53.81	36.05	3.91	1.78	0.08	22.2
	485	Dry, leached, alfilaria predominant	7/10/31	6.75	54.13	33.45	5.67	1.97	0.07	28.1
	518	Dry, leached, alfilaria and grass	8/19/31	6.29	56.68	33.50	3.53	1.48	0.07	21.1
	540	Dry, leached, alfilaria and grass	10/19/31	7.25	58.53	30.10	4.12	1.55	0 08	19.3

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

TABLE 1—*Concluded*

Species	Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:
				Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus	
Ranch No. 17										
White stem alfilaria	126	Bloom	4/16/30	17.99	49.48	18.58	13.95	2.38	0.48	5.0
	180	Wilting‡	5/11/30	14.75	52.03	21.09	12.13	2.58	0.31	8.3
Red stem alfilaria	69*	Green	3/10/30	29.46	45.44	10.56	14.54	2.54	0.60	4.2
	127*	Bloom	4/16/30	14.80	51.48	22.12	11.60	1.92	0.40	4.8
	179*	Wilting	5/11/30	15.65	53.07	20.12	11.16	2.25	0.30	7.5
Broadleaf alfilaria	68*	Green	3/10/30	23.34	53.57	11.35	11.74	2.18	0.39	5.6
	125*	Bloom	4/16/30	11.04	50.54	30.63	7.79	1.37	0.29	4.7
	181*	Wilting	5/11/30	8.95	55.18	26.46	9.41	2.13	0.17	12.5
Bur clover	182*	Green	5/11/30	18.53	49.25	25.48	6.74	1.18	0.30	3.9
	189*	Green	5/14/30	20.77	47.72	25.24	6.27	1.23	0.22	5.6
	124*	Headed	4/16/30	12.55	50.55	32.67	4.23	0.34	0.37	0.9
Soft chess	183*	Wilting	5/11/30	8.36	58.21	31.23	2.20	0.23	0.25	0.9
	240*	Dry	6/16/30	5.29	58.83	31.04	4.84	0.61	0.20	3.0
	70	Green	3/10/30	25.20	47.89	16.35	10.56	1.56	0.53	3.0
Composite sample	241	Dry, bur clover predominant	6/16/30	8.74	55.29	30.23	5.74	1.21	0.14	8.6
	270	Dry, bur clover predominant	8/22/30	7.82	54.95	30.64	6.59	1.44	0.16	9.0
	302	Dry, leached	11/24/30	4.78	53.82	37.35	4.05	1.27	0.05	25.4
Ranch No. 18										
Composite sample	188	Green	5/14/30	12.86	55.69	26.94	4.51	1.01	0.22	4.6
	239	Dry, bur clover predominant	6/16/30	8.59	56.98	28.89	5.54	1.32	0.11	12.0
	269	Dry, bur clover predominant	8/22/30	9.29	56.81	28.07	5.83	1.24	0.10	12.4
	303	Dry, leached	11/24/30	9.95	51.52	33.86	4.67	1.47	0.05	29.4

* The sample numbers marked with an asterisk were used in making figures 1 and 2.

† Where three figures are used in this column the last one may not be significant but is included for typographical uniformity.

‡ Wilting is a term used to denote early stages of drying without reference to whether or not the plants would revive if supplied with moisture.

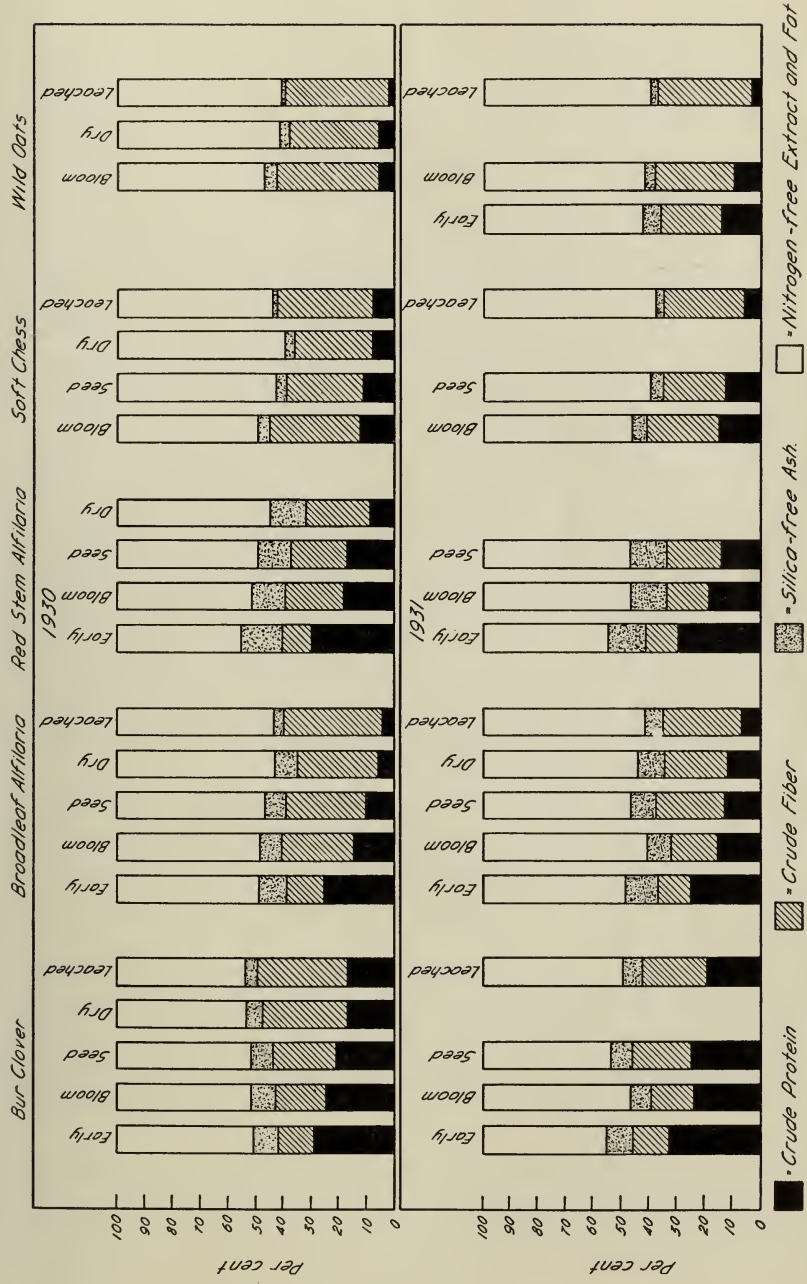

Fig. 1.—Seasonal changes in the composition of the dry matter in the samples consisting of individual species collected during 1930 and 1931. The samples marked with an asterisk in table 1 were used in preparing this figure.

The moisture content of the forage when collected in the early stages varies from 80 to as high as 87 per cent; when the plants are in bloom and seed heads are forming, it averages about 75 per cent; and when they are fully mature and beginning to wilt, about 65 per cent. In the dry, bleached forage the moisture content varies with atmospheric conditions, the usual range of variation during hot, dry weather being from 6 to 10 per cent.

Some variations in composition besides those already mentioned are caused by environmental conditions that result in considerable deviation of individual samples from the mean of any particular group. This, together with the fact that the number of samples for the different stages in figure 1 varied, obscures certain details of the seasonal trend. The data, however, give a fairly accurate idea of the chemical characteristics of the species, regardless of location.

Bur clover is high in protein at all stages of growth, and in the fully matured forage the protein remains at the comparatively high level of about 17 per cent. Even when the clover is leached after drying, the protein rarely falls below 15 per cent. The broadleaf alfilaria and grass species decrease rapidly to low levels in protein as the plants mature and dry, and the seeds shatter. The soft chess contained somewhat more protein in the dry, bleached stage than did wild oats, possibly because the seeds do not shatter readily. Red stem alfilaria compares favorably in protein content with bur clover in the early stages and is significantly higher than broadleaf alfilaria after maturity.

The red stem and white stem alfilaria are outstanding for their high content of silica-free ash, which varied from 11 to 14 per cent in the moisture-free samples. The broadleaf alfilaria and bur clover are very similar in their content of silica-free ash, while the grass species are comparatively low.

The lowest fiber content was found in the red stem alfilaria; the highest, in wild oats. The dry matter of the forage in the early stages, being low in fiber and comparatively high in protein, has the characteristics of a protein concentrate rather than a roughage. This fact has been clearly brought out by the work of Woodman, Blunt, and Stewart,[4] in England.

The year 1930, while not a good feed year, nevertheless furnished sufficient rainfall, satisfactorily distributed, for the forage plants to complete their growth cycle in a reasonably normal manner in most of the area. The data for 1930 (fig. 1) therefore, more nearly represent the normal composition of the species indicated. As the season of 1931 was distinctly below normal in rainfall, the growing period of the plants was

short; and in most instances they dried prematurely. After drying, the forage over the entire area was leached by summer rains. These came early in May and June, whereas in 1930 leaching did not occur until late in the fall, after the forage over most of the area had been dry and bleached for months.

A comparison of the two seasons in figure 1 and table 1 shows that in the early stage the analyses were similar. Later, however, the 1931 samples were consistently higher in protein and lower in fiber. This was to be expected because the plants dried during seed formation before the stage of maturity at which, under normal moisture conditions, there is a rapid increase in fiber.

The data indicate that if rains had not occurred after the feed had dried in 1931, the limited amount of forage produced would have had unusually high nutritive value. There is some evidence that even after leaching, the value of the forage available still was higher than is normally experienced with a similar amount of rain on the dry feed. In the areas which normally produce bur clover, however, that species made so little growth that it was practically all consumed by the time the feed had dried. Since it is the most valuable dry forage, the lack of it, coupled with the rain on the other forage, resulted in markedly inferior dry feed supply in many localities.

Figure 2 shows the calcium and phosphorus content of the same samples represented in figure 1. The calcium content found in red stem alfilaria is extremely high as compared with that found in wild oats and soft chess. Both bur clover and broadleaf alfilaria are relatively high in calcium. The phosphorus content of bur clover decreased to the seed stage and then maintained, throughout the dry period, practically a constant level, which was higher than that found in the other species. The phosphorus content of soft chess in the dry, bleached stage is somewhat misleading, in that most of the samples in 1930 were collected shortly after the grass had cured, when, in a majority of cases, the seeds were only partially shattered. A few samples collected later show a trend similar to that of the broadleaf alfilaria. In 1931 we were unable to get samples of this species, in the dry stage, which had not been leached.

The Ca :P ratio is narrow in the grass species, and extremely wide in the alfilarias. While bur clover is intermediate in this respect, the ratio is wider than is generally considered ideal. In some species, particularly the alfilarias, an increase in calcium, coincident with the reduction in phosphorus content, occurred (see figure 2).

The acid-insoluble ash (not shown in table 1) consisting largely of silica and silicates, is relatively high in wild oats and soft chess, averag-

ing for all stages of growth 3.79 per cent and 3.16 per cent, respectively, of the air-dry samples. In broadleaf alfilaria and bur clover, on the other hand, it is much lower and averages 0.77 per cent and 0.86 per cent, respectively. Cooper, Wilson, and Barron[5] state: "The plants grown on the poor acid soils often contain relatively large amounts of silica and other hard elements with relatively low standard electrode potentials, such as aluminum, manganese and iron. It is believed that the presence of the hard elements influences the palatibility of the pas-

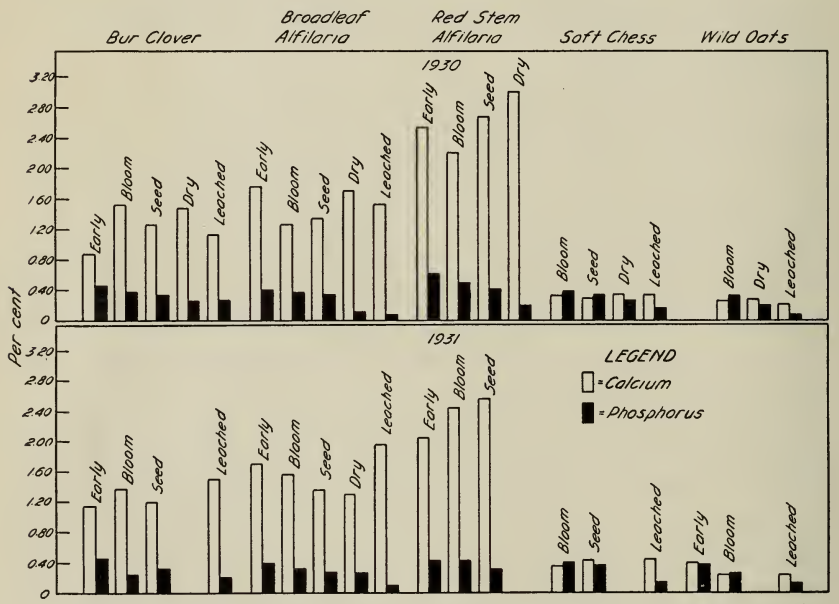

Fig. 2.—Seasonal changes in the calcium and phosphorus content of the samples represented by figure 1.

ture plants. The plants grown on the fertile soils usually contain relatively large amounts of the soft elements such as phosphorus, potassium and calcium and are usually palatable."

Only a limited number of white stem alfilaria samples were obtained. This species appears, however, to resemble the red stem species in chemical composition.

Figure 3 shows in a graphic manner the reason why a range containing bur clover holds its carrying capacity for livestock better than one in which this forage plant is absent.

The data shown in figure 3 were obtained from samples approximating, as nearly as possible, actual grazing on two ranges, one containing bur clover and the other without it. The figure shows the comparatively

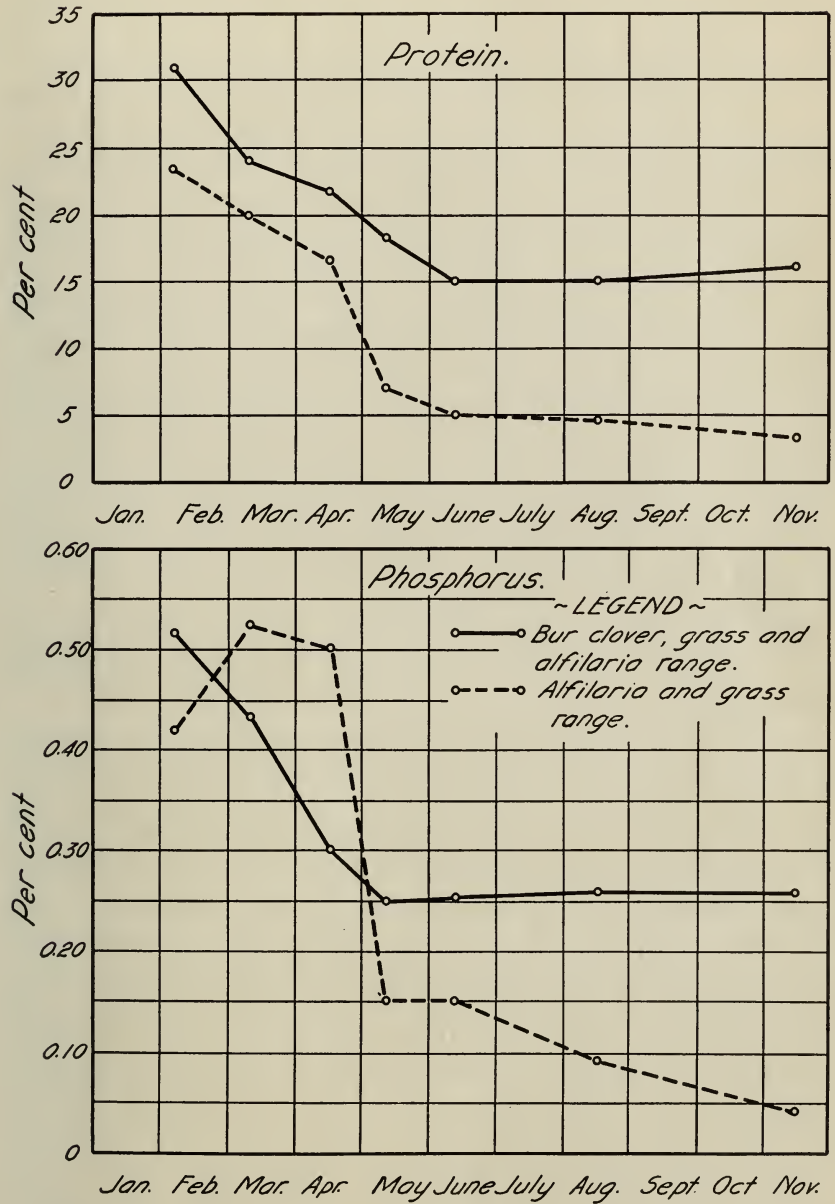

Fig. 3.—Seasonal trend of protein and phosphorus in forage on bur clover, alfilaria, and grass range, compared with an alfilaria and grass range. The samples from table 1 used in preparing this figure were as follows: Ranch 1, bur clover, grass and alfilaria range, Nos. 51, 73, 128, 215, 267, and 297. Ranch 6, alfilaria and grass range, Nos. 53, 77, 108, 165, 227, 262, and 292.

short period when the feed on the range, lacking bur clover, has a satisfactory content of protein and phosphorus, the two main nutrients limited in quantity in most range forage species.

We were interested not only in the varying quality of ranges resulting from differences in the species of plants that make up the major part of the forage, but also in the difference within individual species grown under different soil conditions. Meager information on this point is available because of difficulty in getting comparable samples in stage of growth, degree of seed and leaf shattering, and effect of grazing. Even though large variations caused by conditions of sampling are recognized, it appears significant that the samples of bur clover in which the phosphorus was above the average came, in general, from the heavier soils and best grazing areas. Those that plotted below the average were from land recognized as poorer grazing areas. The lowest phosphorus content in bur clover was found in samples from those areas which, for this species, may be termed marginal, in that good crops are produced only under exceptionally favorable conditions of rainfall. Broadleaf alfilaria samples showed the same general trend, depending on the area from which they had been taken.

Unusually high calcium content of bur clover was found in areas where limestone outcroppings were present (see samples 149 and 209 from ranch No. 10).

Cattle grazing soft chess at the time when the plants are maturing often grasp the heads of many plants and, instead of breaking them off, pull all the stems and even some roots out of the ground. The animals will then bite off the heads and let the stems drop. Sample 171A on ranch No. 4 consisted of soft chess stems which were rejected, and 171B consisted of the heads and a small part of the stems representative of the material eaten. The analyses show the portion eaten to be significantly higher in protein and phosphorus and lower in fiber than the part rejected. Cattle are also commonly observed to graze the heads of wild oats in the seed stage—an illustration of the fact that grazing animals in general consume first the most desirable species and then the most desirable portion of the poorer species. Thus the range forage becomes lower in nutritive value as the season progresses. Bur clover is an exception to this rule because the burs which are available late in the dry season vary but slightly in chemical composition from the combined leaves and stems. The greatest difference is in the ash constituent, the burs being lower in total ash and calcium and higher in phosphorus than the stems and leaves.

VARIATIONS IN CHEMICAL COMPOSITION OF FORAGE FROM ADJOINING BURNED AND UNBURNED AREAS

Cattle, sheep, or deer will usually graze a burned-over area in preference to forage on the unburned land adjoining, at least during the first season following the fire. In order to find some explanation for this if possible by chemical analysis, series of forage samples were collected on ranch No. 5 from a burned and an unburned area, respectively, during 1930 and 1931. The fire had burned the dry forage in the fall of 1929, and where the samples were taken the fire line divided a south slope, making the location ideal from the standpoint of reducing variables, other than the burning, to a minimum.

The forage consisted largely of alfilaria and annual grasses. On the burned area in 1930 the alfilaria stand was very thick, and this species greatly predominated. On the unburned area there was a more even mixture of grasses and alfilaria. The growth of alfilaria was coarse-stemmed. On the unburned area it averaged about 10–12 inches in height; on the burned area, 5 or 6 inches. A proportional difference in height was also found in the wild oats. The chemical composition of these samples is shown in table 2.

In 1930 the phosphorus content of the alfilaria from the burned area, at all stages of sampling except in the leached condition, was approximately double that from the unburned, and the Ca :P ratio in the latter was extremely wide. During 1931, the second year following the burning, there was no significant difference between the alfilaria samples from the two areas, with the exception of the samples collected March 10 and May 9. On March 10 the alfilaria on the burned area was beginning to dry while the plants were still immature, only a few seed heads having been produced. This fact probably accounts for the higher protein content in the sample from that area. In May the phosphorus was higher in the sample from the burned area. The cause, however, may have been the premature drying on this area, with only slight losses from leaching, while the phosphorus content on the unburned was reduced to a greater extent by maturity in addition to leaching. In wild oats there was about 25 per cent more phosphorus in the forage from the burned-over area during 1930. Duplicate samples of this grass were not taken in 1931.

Although the striking increase in phosphorus content of the forage may involve many factors, we do not have sufficient basis for any definite statement. The fact that the alfilaria did not make such a rank growth on the burned area and was more leafy may have accounted for

TABLE 2

PERCENTAGE COMPOSITION OF FORAGE FROM ADJOINING BURNED AND UNBURNED AREAS

Growth stage of sample	Date collected	Oven-dried and silica-free sample												Ratio Ca:P † 1:	
		Crude protein		Nitrogen-free extract and fat		Crude fiber		Silica-free ash		Calcium		Phosphorus			
		B*	U	B	U	B	U	B	U	B	U	B	U	B	U
Broadleaf alfilaria															
Bloom	4/10/30	10.82	10.87	50.38	50.32	31.40	32.83	7.40	5.98	1.05	0.99	0.45	0.24	2.3	4.1
Dry	5/ 8/30	5.00	4.59	61.40	55.16	27.96	32.93	5.64	7.32	1.56	1.74	0.12	0.05	13.0	35.0
Dry	6/12/30	4.36	5.50	61.92	57.73	28.18	28.13	5.54	8.64	1.69	1.71	0.10	0.06	16.9	28.5
Dry	8/19/30	5.20	4.62	62.78	56.70	25.78	30.18	6.24	8.50	1.64	1.79	0 11	0.05	14.9	35.8
Dry, leached	11/18/30	4.46	4.70	59.47	54.21	32.68	36.15	3.39	4.94	1.58	2.04	0.05	0.06	31.6	41.0
Early green	2/16/31	25.86	29.33	50.98	46.35	11.50	11.02	11.66	13.30	1.55	1.77	0.39	0.38	4.0	4.7
Bloom	3/10/31	20.42	11.50	55.27	61.72	15.31	17.24	9.00	9.54	1.31	1.85	0.32	0.33	4.1	5.6
Drying	4/ 7/31	11.51	12 65	60.19	56.94	19.61	21.40	8.69	9.01	1.23	1.20	0.22	0.18	5.6	6.7
Dry, leached	5/ 9/31	10.71	11.58	57.62	52.51	23.08	27.22	8.59	8.69	1.46	1.38	0.17	0.09	8.6	15.3
Dry, leached	6/ 9/31	5.28	5.89	58.94	55.59	28.78	31.30	7.00	7.22	1.80	1.68	0.10	0.06	18.0	28.0
Dry, leached	7/ 8/31	6.12	5.92	59.75	59.27	26.90	27.80	7.23	7.01	2.10	2.11	0.09	0.09	23.3	23.4
Dry, leached	8/19/31	6.10	6.27	63.54	62.57	25.60	26.03	4.76	5.13	2.00	2.07	0.09	0.09	22.2	23.0
Dry, leached	10/16/31	5.63	6.02	63.63	63.97	26.20	24.90	4.54	5.11	1.95	2.14	0.09	0.09	21.6	23.7
Wild oats															
Bloom	4/10/30	8 06	7.99	56.75	55.04	31.00	33.13	4.19	3.84	0.27	0.21	0.30	0.24	0.9	0 9
Dry	5/ 8/30	4.84	5.25	55.59	54.36	37.15	38.16	2.42	2.23	0.22	0.20	0.23	0.16	1.0	1.3
Dry	6/12/30	3.49	3.29	60.23	56.46	32.66	35.71	3.62	4.54	0.32	0.19	0.24	0.18	1.3	1.1

* B is burned area, U is unburned.

† Where three figures are used in this column the last one is not significant but is included for typographical uniformity.

the difference. The amount of phosphorus in the plant ash could not have been very large, as there was probably not over a half ton of dry forage per acre on the range, when it burned, which contained about 0.1 per cent of phosphorus. It therefore seems impossible to attribute any fertilizing effect to this small amount of ash. The forage from the area throughout the two-year sampling period covered in this report, however, was generally lower in phosphorus than that from most other sampling areas. In the spring of 1932 opportunity was presented to collect forage samples from burned and unburned areas on the more fertile soils of ranch No. 1, and on the University Farm. This was done with the three species of alfilaria and with bur clover. Sampling was limited to the months of March and April. No significant difference was observed in the phosphorus content in the samples on these places although the stock were observed to give definite preference to the forage on the burned area. This question of palatability, therefore, probably involves many factors. Significant response in growth has been obtained from top dressing ranges with phosphorus, in many grazing areas of the world where moisture is not such a serious limiting factor as on our ranges, and the palatability of forage grown on such areas is increased. Artificial fertilizers are being tried with some success on favorably situated limited pasture areas in California. Each soil area constitutes a separate experiment for trials of this kind because the action of different soils varies greatly in chemically fixing the ingredients of the fertilizer so as to make them temporarily at least, unavailable for plant food. There is need for well-planned research on these questions.

BROWSE

At elevations higher than those occupied by the regular sampling areas, livestock feed to a greater or less extent on various species of browse. The so-called sweet birch or bluebrush (*Ceanothus integerrimus*) is generally recognized as the most valuable feed among this class of plants in the Sierra Nevada Mountains.

We became interested in the fact that this plant began to lose its palatability in the latter part of the summer, when there still remained an ample supply of apparently good feed. At this time, if animals are left in the area, they will wander about in search of other forage and rapidly lose the gains made earlier in the season. The palatability becomes noticeably lowered in August after the seeds have fallen. With the cooperation of L. S. Smith, Range Examiner, U. S. Forest Service, four samples were collected from May to September, 1929. In 1930,

TABLE 3

PERCENTAGE COMPOSITION OF SAMPLES OF SWEET BIRCH (CEANOTHUS INTEGERRIMUS) AND BITTERBRUSH (PURSHIA TRIDENTATA)

Sample No.	Stage of growth	Date collected	Oven-dried and silica-free sample						Ratio Ca:P † 1:	Alkalinity cc $\frac{N}{10}$HCl
			Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Calcium	Phosphorus		
			Sweet birch							
10	Leaves and shoots	5/ 9/29	29.16	50.72	13.65	7.47	1.29	0.56	2.3	900
13	Leaves and shoots (prime for grazing)	5/26/29	20.75	56.22	15.80	7.23	1.04	0.24	4.3	988
40	Leaves and seed pods	8/29/29	13.59	60.14	17.30	8.97	2.23	0.13	17.1	1,560
42	Leaves (turning in color, palatability low)	9/27/29	12.78	72.20	8.77	6.25	1.63	0.08	18.9	1,302
192	Sec. 18, early bloom, leaves and shoots	5/28/30	23.08	60.85	10.27	5.80	1.37	0.27	5.1	1,130
193	Sec. 33, bud stage, leaves and shoots	5/28/30	28.89	56.18	8.34	6.59	1.30	0.37	3.5	1,060
244	Sec. 18, leaves and shoots	6/21/30	22.54	60.08	9.97	7.47	1.93	0.21	9.2	1,430
245	Sec. 33, leaves, some shoots	6/21/30	27.25	58.32	12.51	7.92	1.11	0.32	3.5	1,140
246	Sec. 18, leaves	7/ 8/30	21.57	61.95	9.23	7.25	1.57	0.17	8.3	1,260
247	Sec. 33, leaves and seeds	7/ 8/30	24.39	59.60	9.48	6.53	1.77	0.22	8.0	1,370
249	Sec. 18, leaves, few seeds	8/ 2/30	16.78	65.18	12.80	5.24	1.47	0.13	11.4	1,260
248	Sec. 33, leaves and seeds	8/ 2/30	18.96	59.50	14.66	6.88	1.20	0.17	7.1	1,240
272	Sec. 18, leaves, few seeds	8/22/30	16.95	65.36	10.88	6.81	2.48	0.12	20.7	1,690
271	Sec. 33, leaves, few seeds	8/22/30	18.25	64.66	10.55	6.54	2.22	0.13	17.1	1,550
273*	Mostly seeds	9/10/30	14.48	53.56	26.07	5.89	1.33	0.13	10.2	1,035
274*	Seeds only	9/10/30	13.33	51.09	30.21	5.37	0.73	0.19	3.8	800
276	Sec. 18, leaves only	9/19/30	14.26	71.86	6.87	7.01	2.03	0.11	18.5	1,370
275	Sec. 33, leaves only	9/19/30	17.16	68.03	7.02	7.79	2.06	0.13	15.6	1,530
			Bitterbrush							
191	Leaves and twigs	5/19/30	14.98	62.79	18.73	3.50	0.72	0.24	3.0	600
250	Leaves	8/ 6/30	13.27	65.26	16.07	5.40	1.52	0.18	8.5	1,110
278	Leaves	9/14/30	11.60	68.22	16.24	3.94	1.15	0.13	8.8	860

* Samples 273 and 274 are additional samples not included in the series representing the material grazed, as the seeds were mature and not eaten at this time.
† Where three figures are used in this column the last one may not be significant but is used for typographical uniformity.

samples were collected at approximately three-week intervals, beginning May 28 and extending to September 19. The latter series of samples were collected from two areas. The first area, designated as Section 18, was a fairly open south slope, with shallow rocky soil in yellow-pine type. The second area, Section 33, was in dense mixed conifer type, mixed yellow pine and Douglas fir, on fairly good soil. Section 33 location was on a more gentle slope, which, together with deeper soil and more shade, made it a moister location. The forage was about three weeks later in reaching the same stage of development as that in Section 18.

An attempt was made to collect samples representing as nearly as possible the material as taken by the animals.

The results of the analyses of this plant are given in table 3.

With advancing stages of maturity, the percentage of protein decreased and the nitrogen-free extract and fat increased. The crude fiber varied somewhat, undoubtedly because of variation in the amounts of leaves, stems, and seeds included in the samples. No definite trend was noted in the amount of silica-free ash. The percentage of phosphorus declined steadily as the season advanced.

An interesting variation was exhibited in the calcium content. In 1930, both sampling areas showed a marked increase in the calcium of the samples collected August 22, as compared with the previous collection, an increase almost identical with the results obtained with sample 40 in 1929. This great increase in calcium, together with the decrease in phosphorus, brings the Ca : P ratio to the season's maximum, and coincides closely with the time cattle were observed to leave the browse.

The level of phosphorus in the browse during August and September is similar to that of rations fed experimentally at the Minnesota Experiment Station,[6] which resulted in the loss of weight, suspended ovulation, and bone craving in cows, even though they received as much as 50 per cent more feed than is normally calculated for maintenance. The Ca : P ratio in the Minnesota experiment, moreover, was much more favorable to normal metabolism than the wide ratio found in the sweet birch. The sweet-birch feed was fairly well balanced in regard to protein and energy, the moisture content was between 60 and 65 per cent, and the fiber content was low indicating that the leaves were still succulent and should be highly digestible.

Table 3 appears to show that samples from Section 33 were higher in protein and phosphorus than those from Section 18. When, however, we plot the two series on graph paper, giving Section 18 a lag of one month over Section 33, to compare approximately the same stages of growth, the trends become very similar.

The first sample collected in 1929 was somewhat earlier than the first sample in 1930, and both the protein and phosphorus were considerably higher. The last sample taken in 1929 was later than the last collected in 1930, and both protein and phosphorus were lower. At corresponding times in the two years the results were in close agreement and the trends were the same. The higher fiber content in 1930 can be attributed to the larger amount of seeds and twigs included in the samples. Cattle ate the seeds in 1929 but consumed a very small percentage of seeds in 1930. This was true all over the area. An examination of the seeds revealed a high percentage to have been damaged by an insect larva. As the larvae had already emerged when the condition was noted, the species was not identified. In the capsules attacked, the seeds were completely destroyed, and the capsules filled with excrement.

This insect invasion may have been responsible for the cattle's not eating the seed crop in 1930.

The most striking difference between the leaves on the one hand, and the capsules and seeds on the other, is the high fiber content of the latter. The calcium content of the seeds is also lower, and the phosphorus is lower than would be expected, in part, perhaps, because of the insect damage. The phosphorus is, however, significantly higher in the sample of pure seeds than in the leaves.

Analyses of three samples of bitterbrush (*Purshia tridentata*) are also given in table 3.

Sample No. 191, consisting of leaves and twigs, was collected near Truckee on an open browse range at an elevation of 5,400 feet. Sheep had just been put on the range. The lambs were eating the browse eagerly, whereas the ewes were grazing mostly, although they too, were browsing somewhat. This browse was not considered by the range examiner at this time to be in the best stages for grazing.

Sample No. 250, consisting of leaves, was collected as browsed by sheep from plants on a gravelly south slope at 6,250 feet elevation near Truckee.

Sample No. 278, consisting of leaves, was collected at Sierraville in the same manner as sample 250.

Although the samples analyzed were secured from different areas, a definite downward trend in protein and phosphorus during advancing maturity is apparent. A lower calcium content than in the sweet birch resulted, however, in a closer ratio between calcium and phosphorus.

GRASS AND CLOVER SAMPLES COLLECTED IN THE HIGHER ELEVATIONS

A few grass and clover samples were collected from mountain meadows east of Red Bluff in the vicinity of Mineral. Table 4 shows their chemical composition.

Sample No. 8 included many different species, among which oat grass (*Danthonia americana*) and various true clovers (*Trifolium* sp.) apparently constituted the major species grazed by the cattle. The forage at this particular place was closely grazed. An attempt was made

TABLE 4

Percentage Composition of Range Forage Collected from Mountain Meadows

Number and description of sample	Date collected	Field moisture	Oven-dried and silica-free sample						
			Crude protein	Nitrogen-free extract and fat	Crude fiber	Silica-free ash	Phosphorus	Calcium	Ca:P 1:
8. Composite, green	7/11/29	.....	14.41	.....	.....	3.59	0.20	0.82	4.1
242. Grass composite, green	6/20/30	68.5	12.62	53.61	27.21	6.56	0.20	0.48	2.4
257. Grass composite, green	8/13/30	55.8	10.15	56.79	28.15	4.91	0.14	0.93	6.6
243. Alsike and red clover, green, in bloom	6/20/30	82.4	22.94	49 81	17.11	10.14	0.28	1.47	5.3
256. Alsike and red clover, fully matured	8/13/30	71.8	16.63	51.03	23.74	8.60	0.17	1.24	7.3

to obtain the sample in the manner in which the cattle were actually grazing it. Because this sample was lower in phosphorus than green samples taken in other areas, it was decided to obtain additional forage samples in 1930 from this area. Samples 242, 243, 256, and 257 were thereupon taken in June and August of 1930. Samples 242 and 257 were grass composites containing about the same forage species as No. 8. Samples 243 and 256 were composite samples of alsike clover (*Trifolium hybridum*) and red clover (*Trifolium pratense*). These, with the exception of sample No. 243, were low in phosphorus compared with green forage on the valley ranges. This limited amount of information, together with that on the browse, indicates the existence of nutritional problems in the higher elevations.

EFFECT OF RAIN ON DRY FORAGE

The fact has long been recognized that appreciable amounts of rain on forage, particularly annual plants that have matured and dried, greatly reduce their feed value for livestock. In our studies we became interested in the actual nutritive constituents that were leached out of the plants by the rain, and the effect on the digestibility of those which remained. Work has been published at this station by Guilbert and Mead[7] on the digestibility of bur clover as affected by exposure to sunlight and rain, and by Guilbert, Mead, and Jackson[8] on the effect of leaching on the nutritive value of forage plants.

Their studies on bur clover showed that even when cut in advanced stages of maturity it had a higher coefficient of digestibility than most hays. Weathering of the plant, which included exposure to rain, resulted in a decrease in digestibility of each nutrient except crude fiber. The evidence presented indicates that the loss of soluble constituents caused by the rain may account for the greater part of the decrease in digestibility. The bleaching and leaching also apparently decreased the palatability of the bur clover used in the digestion experiments. The influence of the decrease in digestibility on gains in live weight, depending on the amount of forage consumed daily, was also discussed. The bur clover was cut at the late seed stage and divided into three lots. Lot 1 was cured one day in a thin layer and then cured in cocks for 6 days. Lot 2 was exposed in a thin layer for 21 days, in the course of which it was wet twice by rain totaling 0.31 inch. Lot 3 was exposed in a thin layer for 34 days and was wet three times during that period by rain totaling 0.78 inch. The significance of the difference found in the digestible composition of the three lots could be demonstrated by a hypothetical case wherein a 1,000-pound steer eats 25 pounds each of the different lots. The computed gains would have been 1.47, 0.87, and 0.62 pounds per day, respectively, for each of the three lots of clover.

In case the total dry matter consumed daily under such circumstances was limited to 20 pounds, the computed gains would be reduced to 0.8 pound, 0.3 pound, and no gain, respectively, for each of the lots. We still do not have satisfactory data on the amount of forage an animal will graze per day from the range under various conditions.

Late rains prevailed over a large area in California in 1929 and again in 1931. Greater amounts of supplements are necessary to finish cattle on such spoiled feed and even to maintain breeding stock in satisfactory condition. It is therefore important to understand what hap-

pens to the feed value of different species of plants in order to supply necessary supplements most efficiently and economically. Leaching experiments were conducted with bur clover, oat hay, and naturally cured range forage under laboratory conditions to show the relative losses of the various constituents. Some of the experiments represented nearly complete extractions of the soluble constituents but were probably not in excess of conditions occurring on the range when the feed remains saturated for one or two days and is leached by intermittent showers totaling one to three inches or more of rainfall. The greatest percentage loss was in the silica-free ash and varied from 25 to 67 per cent. Chlorine was lost in greatest amount, reaching 67 per cent in oat hay and 86 per cent in bur clover. This fact is in agreement with the observed increased salt requirement of stock after feed has been damaged by rain.

In both bur clover and alfilaria the calcium was not significantly affected; but phosphorus was distinctly lowered, particularly in the case of the bur clover leaves and stems. This change tends to widen the calcium-phosphorus ratio.

A larger percentage of calcium was lost in the grass species. The nitrogen-free extract lost varied from 6 per cent, in a sample of soft chess, to 35 per cent, in bur clover stems and leaves.

The decrease in crude protein varied from 1 per cent of the total in oat hay to 16 per cent in bur clover and 18 per cent in soft chess. Because, however, of greater loss of other constituents, this decrease does not show in the analysis, and the percentage of protein in the remaining dry matter may even be increased. Ether extract is influenced but slightly.

As the crude fiber remained entirely in the residue, its increase there accordingly constitutes an index to the loss of other constituents. An increase of 3 to 6 per cent in crude fiber coincided with a loss of 10 to 20 per cent in total solids.

For more detailed results of these experiments the reader is referred to the original publications.

The effect of rain on the composition of field samples is difficult to ascertain accurately because loss of leaves may be occasioned by the beating effect of the rain. One cannot state with certainty that the leached sample is comparable in all other respects with the one previously obtained. As shown by samples of wild oats Nos. 217 and 299 on ranch No. 1, and by samples of broadleaf alfilaria Nos. 261 and 291 on ranch No. 6, the results from field samples agree, however, with the laboratory experiments and definitely indicate the composition of the forage available for grazing.

SIGNIFICANCE OF VITAMIN A IN RANGE FEED

The fact that cattle require vitamin A has been demonstrated at this station by Mead and Regan,[9] who studied deficiencies of rations devoid of roughage for calves until the animals were two years of age. These workers also showed that the quantitive requirement was by no means so insignificant as many have heretofore believed. Jones, Eckles, and Palmer[10] showed vitamin A to be an indispensable factor in the diet of calves. Bechdel, Honeywell, and Dutcher[11] also presented evidence of abnormalities in heifers fed a ration deficient in vitamin A. Halverson and Sherwood[12] have quite definitely established that so-called cottonseed poisoning in cattle really results from the nutritive deficiencies of the rations fed, particularly in vitamins, rather than from gossypol toxicity. The condition can be relieved and cottonseed maintained at the same level of intake by supplying the animal with green feed or other source of vitamin A, the primary deficiency.

Mild evidence of cottonseed poisoning has been manifest in long dry-feed seasons on the range where cottonseed cake was the only supplement fed.

The liver is a storehouse for vitamin A in the body, and the color test with liver tissue indicates somewhat the state of depletion of the animal in the vitamin at the time of its death. Liver samples were taken from 5 steers at the time of slaughter in October. Steer No. 1 had pastured along a river bottom and had access to bermuda grass and other green forage plants throughout the season. Steers 2 to 5 had subsisted on dry range feed and a small amount of cottonseed meal from April to July 1. From this time until slaughter these animals received in addition to the dry range feed 1 pound of alfalfa meal daily and an average of 3 pounds of cottonseed meal and 5.5 pounds of ground barley daily. The livers of 2 rats on a diet rich in vitamin A and one sample of cod-liver oil were also included in the test as checks.

The method of extracting the liver oil before making the test is, in general, that given by Moore.[13] The liver samples were minced, placed in flasks with about twice their bulk of 5 per cent potassium hydroxide, and allowed to stand in a cold room (40°–42° F) for several days. Upon removal from storage the samples were gently warmed on a hot-plate and shaken until practically all the liver tissue went into solution. About 1 cc of 50 per cent alcohol was then added for each gram of liver tissue. After cooling, the solutions were transferred to separatory funnels and extracted once with about three volumes of ethyl ether.

Nearly all the liver oil was thus extracted, as evidenced by the faintness of the reaction obtained after a second extraction. The addition of alcohol greatly facilitated the extraction and the separation of the ether layer from the emulsion formed after vigorous shaking.

The alkali was then drawn off, and the ether washed at least three times with distilled water. The ether was then filtered into Soxhlet flasks, through anhydrous sodium sulfate, to remove the water. It was then distilled off, and the flasks containing the liver oil were placed in vacuum desiccators over calcium chloride. The air in the desiccators was first washed out with carbon dioxide, and then the oils were allowed to stand in vacuo for several hours to remove any moisture. The dried material appears as an amorphous yellow-orange colored mass. This material was then dissolved in chloroform, transferred to 10 cc volumetric flasks, and diluted to the mark with chloroform.

The antimony trichloride reagent was made by dissolving antimony trichloride in chemically pure chloroform at room temperature (30 grams of antimony trichloride in 100 cc chloroform).

Quantitative comparisons were made by dilution of the chloroform solutions until the blue color formed with 2 cc of antimony trichloride reagent and 0.2 cc of the test solution was just faintly discernible. The solutions were then calculated back to the amount of liver tissue which they represented. On this basis the minimum amounts of liver tissue to produce a detectable reaction were as follows:

	Milligrams
Rat livers	5
Liver of steer No. 1	4
Liver of steer No. 2	20
Liver of steer No. 3	43
Liver of steer No. 4	185
Liver of steer No. 5	257

The vitamin A concentrations in the livers of the two rats on a diet rich in vitamin A, and in the liver of steer No. 1 having access to green feed were approximately equal.

The concentration in the liver of steer No. 1 was 5 to 64 times as high as that in the livers of the steers 2 to 5.

Steers 2 to 5 may all have had a feed of alfalfa or other hay after arrival at the slaughter house in San Francisco, which could have altered in some degree the vitamin A concentration in their livers. Barley and cottonseed meal are known to be deficient in vitamin A. Alfalfa meal contains the vitamin but feeding 1 pound daily in addition to the

range feed did not result in a concentration in the liver comparable to that obtaining in the steer receiving green forage. The evidence, though meager, substantiates the supposition that the dry range feed is deficient in this dietary factor.

A sample of cod-liver oil estimated to contain not less than 500 rat units per gram was tested by use of the same technique as employed with the liver samples. The minimum quantity of cod-liver oil necessary to produce a faint blue color was 0.75 mg or a little less than one-fifth as much as the most potent liver sample.

DIGESTION EXPERIMENTS WITH RANGE FORAGE

Chemical analyses of feed stuffs, though valuable in indicating limiting factors such as protein and minerals, do not give information as to the amounts of the various nutrients actually available to the animal. The digestibility of the nutrients in different feeds varies greatly; and the values for productive purposes, even of the digestible portions, are different in roughages from those in concentrates. Thus, a pound of digestible nutrients in grains is more valuable for the production of growth and fat than an equal amount of digestible material from hay or straw. As a further step in determining the nutritive value of range forage, digestion experiments were undertaken; and the results of the five trials thus far completed are presented herewith. Three of these trials have been reported in detail in an earlier publication.[7]

The first trial [14] was with range grass collected by A. W. Sampson of the Division of Forestry in Mendocino County in September, 1926. The forage consisted almost entirely of grasses, dry and bleached, with most of the seed heads shattered; and it was estimated to contain about 70 per cent soft chess (*Bromus hordeaceus*). The palatability was so extremely low that the sheep used in the experiments had to be starved to it, and even after two weeks the maximum amount consumed was slightly under one pound daily. Five wethers were used, varying in weight from 65 to 90 pounds. All lost weight during the trial (3 to 5 pounds in ten days). The preliminary period was five days, and the collection period ten.

The second, third, and fourth trials were with bur clover which had been exposed to various degrees of weathering and to rain. The treatment of the three lots of bur clover is described under the section headed "Effect of Rain on Dry Forage."

The fifth trial was conducted by A. Folger, with dry, bleached, and leached alfilaria, collected from a field which had not been grazed on the Adobe Ranch, Madera County, August 19, 1931. The material was col-

lected by raking the alfilaria patches with hand rakes. A small amount of grass, weeds, and foreign material was included. It was subsequently picked over by hand to remove most of the dirt and foreign material,

TABLE 5

PERCENTAGE COMPOSITION OF RANGE FORAGE USED IN DIGESTION EXPERIMENTS: DRY BASIS

Trial No.	Forage	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber	Total ash	Calcium	Phosphorus
1	Dry, bleached grass	4.15	52.00	1.23	36.20	5.61	0.20	0.17
2	Bur clover, mature, green, cured as hay	17.71	46.93	3.34	22.97	9.05	.....	0.32
3	Bur clover, exposed to sun 21 days and to 0.31 inch of rain	17.35	46.27	2.54	25.11	8.72	1.24	0.30
4	Bur clover, exposed to sun 34 days and to 0.78 inch of rain	17.86	44.84	2.22	27.48	7.61	1.30	0.29
5	Dry, bleached, and leached alfilaria	4.89	54.34	1.23	31.08	8.46	.....	.....

TABLE 6

AVERAGE PERCENTAGE DIGESTIBILITY

Trial No.	Forage	Dry matter	Crude protein	Nitrogen-free extract	Ether extract	Crude fiber
1	Grass	49.7	−10.5	52.0	43.7	63.0
2	Bur clover	64.2	74.1	70.9	56.9	51.5
3	Bur clover	59.2	68.0	64.1	40.9	50.7
4	Bur clover	55.7	63.7	59.9	23.6	52.4
5	Alfilaria	39.9	−28.5	47.7	43.3	45.5

TABLE 7

POUNDS OF DIGESTIBLE NUTRIENTS IN 100 POUNDS OF DRY MATTER

Trial No.	Forage	Crude protein	Carbohydrate	Fat	Total*
1	Grass	.....	49.9	0.54	51.1
2	Bur clover	13.1	45.1	1.89	62.5
3	Bur clover	11.8	42.4	1.04	56.5
4	Bur clover	11.4	41.3	0.52	53.8
5	Alfilaria	.....	40.0	0.53	41.2

* The total included digestible fat × the factor 2.25.

so that the forage fed to the animals was nearly pure alfilaria, of the broadleaf and red stem species. After drying, this forage had been leached by several rains, which probably totaled over two inches. As the palatibility was low, the maximum the sheep could be induced to eat was about 1¼ pounds daily. Four wethers which varied in weight from

116 to 126 pounds each were used in the experiment. The preliminary period was ten days and the collection period fifteen, and all the sheep lost weight during the experiment.

The chemical composition, coefficients of digestibility, and digestible nutrients in 100 pounds of each lot of forage used in the digestion trials are given in tables 5, 6, and 7.

Reference to the tables shows not only that the protein content of the dry grass used in trial 1 and of the alfilaria used in trial 5 was very low, but that negative values were found in each case for digestibility. This is explained by the fact that some nitrogenous waste products are ex-

TABLE 8

RELATIVE VALUE OF THE FORAGES USED IN THE DIGESTION EXPERIMENTS FOR THE MAINTENANCE OF A 1,000-POUND BEEF COW

	Digestible crude protein	Total digestible nutrients
	pounds	*pounds*
Daily requirement of 1,000-pound beef cow in calf	0.7-0.9	9.0-12.0
Trial 1 Grass 20 pounds	None?	10.2
Trial 2 Bur clover 17 pounds	2.22	10.6
Trial 3 Bur clover 18.5 pounds	2.18	10.4
Trial 4 Bur clover 19.5 pounds	2.12	10.5
Trial 5 Alfilaria 25.5 pounds	None?	10.5

creted by way of the intestinal tract, and this, coupled with the fact that feed consumption and the percentage of protein in the feed was small, resulted in the recovery of more nitrogen in the feces than was consumed in the feed. With larger feed intake, such as no doubt would occur under natural grazing by animals accustomed to such feed, positive values would probably be obtained. In any case the amount available would be much too low to meet the animal's requirements.

The bur clover, on the other hand, contained sufficient protein of relatively high digestibility to meet the needs of an animal.

The decrease in the percentage of the digestible nutrients, caused by exposure to rain, is clearly shown in the trials with bur clover. The low digestibility of the alfilaria which had been leached by rain is particularly striking.

As illustrative of the relative values of the different forages used in the digestion experiments, the requirements for wintering a 1,000-pound beef cow in calf, according to the Morrison feeding standard, together with the number of pounds of dry matter from each forage to furnish sufficient total digestible nutrients, are shown in table 8.

Since the dry feed contains some moisture, the total feed intake would have to be 8 to 10 per cent more than the figures indicated. The bur clover, when consumed in amounts varying from 17 to 19.5 pounds of dry matter, would furnish not only sufficient total digestible nutrients for the energy requirement but also abundant protein. The dry grass and alfilaria, on the other hand, would furnish little or no available protein, and about 2 pounds of high-protein cottonseed cake or its equivalent in other protein supplements would be required to meet the minimum requirement.

Gains in weight on any of these feeds, even after the minimum protein requirement has been provided, would be conditioned by the amount of forage, over that required for maintenance, which the animals would be capable of consuming. Generally cattle will daily consume palatable dry feeds in amounts equivalent to approximately 3 per cent of their live weight. Thus good gains could be expected without supplement from forage similar to the bur clover used in trial 2. Lower gains would be expected on the bur clover used in trials 3 and 4, because of decreased digestibility and palatability.

It is not possible to estimate with any degree of certainty the amount of forage, such as the grass or alfilaria used in trials 1 and 5, which would be eaten. When the minimum protein was furnished, the grass would probably permit some gain; but little more than maintenance could be expected from the alfilaria. This nutrient content is representative of alfilaria probably at or near its lowest value and explains the extremely poor results obtained after severe damage by rain.

OBSERVATIONS ON PROBLEMS CONNECTED WITH REPRODUCTION

Hart and Guilbert[15] have already reported at some length on factors affecting percentage calf crop in range herds. Their report stressed the effect of possible mineral deficiency, particularly phosphorus. Laboratory experiments with rats on the effects of varying calcium and phosphorus intake, published by Guilbert and Hart,[16] showed that the estrous cycle and reproduction were affected by low phosphorus and also that a high ratio of calcium to phosphorus intensified deficiency of the latter. The idea that any nutritional deficiency may be a limiting factor in reproduction has been developing for a number of years, and evidence which has been accumulating supports this conception. Thus the existence of low protein levels in range feeds caused us to repeat laboratory experiments with rats on low protein diets, as had been previously done with diets low in minerals. The results of these experi-

ments, published by Guilbert and Goss,[17] demonstrate that protein levels of 3½ to 5 per cent resulted in cessation of estrum or in long and irregular cycles. An inadequate level of protein was secured which permitted estrum in some individuals. These animals were subjected to breeding tests with normal males, but no litters were produced. The lack of fertility was of three general types: the failure to mate during estrum when placed with normal males; infertile matings with recurrence of estrum; and fertile matings, followed by death of the embryos.

Investigations of recent years have brought out the importance of vitamin A in maintaining high reproductive efficiency. Hart, Steenbock, Humphrey, and Hulce,[18] in their paper reinterpreting the results of the original experiments on the nutritive value of rations restricted to the wheat plant for cattle, showed that vitamin A and calcium were the limiting factors in obtaining normal reproduction. This fact was manifested by calves being born dead, or very weak at birth and dying soon thereafter. Retention of the placenta was also commonly observed in these cases. Halverson and Sherwood,[12] in their investigations on the feeding of cottonseed meal to cattle, produced typical symptoms of so-called cottonseed meal poisoning not only with cottonseed but also with peanut, soybean, and linseed meal when fed in rations containing a mineral mixture and a poor roughage. They showed that this condition was not caused by the presence of a toxic substance in cottonseed meal, and they presented evidence that the failure of these rations resulted primarily from a deficiency of vitamin A. Though they showed reproductive difficulties similar to those in the Wisconsin experiments, their data are confusing because abortion infection existed in their experimental cows. Nevertheless, the lowered body weight at birth, weakness, and mortality in the offspring, and the presence of eye lesions in the calves from cows on the rations low in vitamin A, as compared with the controls, are significant.

In the three-year period during which we have been conducting this work, our attention has been called to a variety of conditions involving reproduction in limited or wide areas. Among these may be mentioned high mortality in newly born pigs, lambs, and calves, associated with enlarged thyroid glands. This condition has been limited to an area in Shasta County and to one in Modoc County. It is caused by iodine deficiency in the feed and water supply of the pregnant females in those regions.

There has been evidence of abnormalities late in gestation over much wider areas, not associated with iodine deficiency. In the fall and winter of 1929 and 1930, many cases of calves having been born dead or dying

soon after birth were reported. Retention of the placenta was also associated with the condition, particularly in cows calving in November and December, on dry feed, the lateness of the rains having prevented green feed from starting until January. This condition apparently disappears when good feed becomes available.

We collected blood samples from a number of the affected cows in several herds and found the situation complicated by the existence of

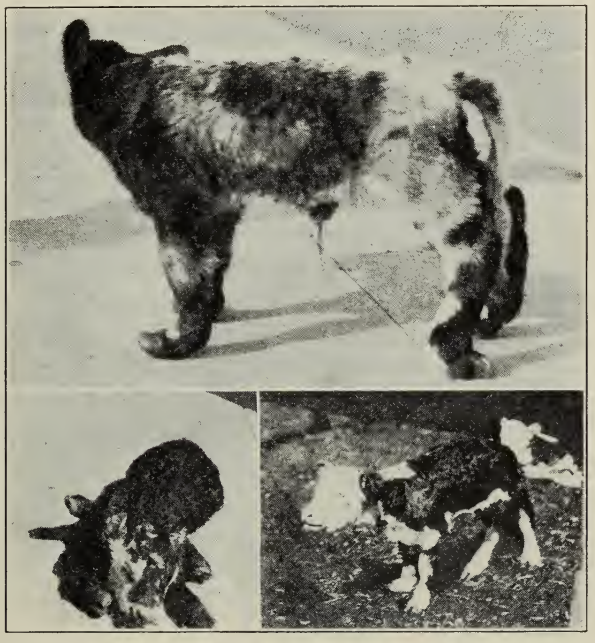

Fig. 4.—"Acorn calves" of different breeds. The animal shown in the lower left was most severely deformed.

occasional reactors to the agglutination test for infectious abortion. In one herd, where 25 cows calved, with 8 having retained placentas, blood samples were taken from the entire herd of 52 head, and all were negative. Though the evidence is not satisfactory to prove feed deficiencies as the cause of this condition, there are sufficient data to lead us to suspect that this may be the case.

In 1931 rains came in December and cold weather retarded the growth of green feed. Where pregnant cows were given supplements early, they held up on the limited amount of forage, with small losses during calving. Where supplements were not given until the animals were very poor, instances of heavy losses of calves were reported. This is further evidence that dry feed must be supplemented late in the

season to prevent the cows from becoming too thin during the calving period.

One other condition known as "acorn calves," which occurs over wide-spread areas in the range lands, has been investigated. It is illustrated in figure 4. In general these calves are born with very short legs caused by abnormally short shafts of the long bones of the fore and hind legs, particularly the humeri and femurs. The head frequently appears out of proportion and shows an upturned or lateral turn of the nose with undershot jaw. The bending of the legs of these calves gives the impression that the muscles and tendons develop normally, but that the shortness of the bones allows the joints to bend abnormally before receiving muscular support.

The name "acorn calves" originated because of the rather general impression that the condition resulted from the dams' eating too many acorns during gestation. It apparently does occur more commonly in the oak belt of the Sierras than elsewhere. In general, there is a preponderance of the grass species, some alfilaria, and relatively little bur clover in these areas, so that the dry feed is of inferior quality.

The condition is manifested more frequently in poor feed years, and appears to be especially liable to occur when animals are confined to the same area throughout the year, so that a long period on dry feed is involved. Opinions of stockmen are somewhat conflicting, in that some report numerous cases following poor feed conditions when relatively few acorns were available, and cite instances of practically no losses after a year of heavy acorn mast. Others associate the appearance of deformed calves with years of heavy masts. We have, however, reliable reports of the condition in calves from cows which did not have access to acorns. Of 9 heifers that were kept together in the same field throughout the summer and fall of 1930, 5 produced deformed calves. The forage in this field consisted largely of annual grasses, and the cattle did not have access to acorns during the gestation period.

We have considered the possible relation of this condition to the achondroplasia-like condition in Dexter cattle known as bull-dog calves which has been reported upon at length and definitely associated with heredity by Crew.[19] These calves are always born dead and usually premature, and the anatomical alterations are much more extensive, including umbilical hernia. The condition is always associated with excessive fluid in the fetal membranes. This may be recognized as early as the third or fourth month, and obliterates the hollow in the flank. The cow then loses the excess water through the vagina, but the fluid soon accumulates again and dribbles until finally the fetus is aborted. The

placenta comes away in small fragments. Herdsmen say there is no afterbirth in these cases, but lochial discharge lasts longer than normal. The death of the fetus, if near term, is associated with dropsy and difficult parturition. None of these conditions are observed to be associated with "acorn calves." All that we have observed were born at term alive, and many will live if helped to nurse their dams during the first weeks of their lives. Apparently there is a gradation of the condition from practically normal to extreme deformity. The calves are always undersized and not economical animals to raise, and are, therefore, usually destroyed.

Wriedt[20] describes a so-called "bull-dog" calf condition in the Telemark breed of cattle in Norway which was traced to one bull, Niklas 481, born in 1899. These cases appear more nearly to resemble "acorn calves" than those reported by Crew. We have considered the possibility that inheritance may be the cause of "acorn calves." In the light of all the data we have accumulated, however, such an explanation does not seem tenable. At least, rigorous environmental conditions must exist for the condition to be manifested.

Although no definite history of the cattle is available, the stock has necessarily come from greatly varied sources over the wide area in which deformed calves appear. The sources of the bulls used are also widely varied, and no such hereditary anomaly has been associated with the pure breeds from which the sires are usually drawn, namely, Hereford and Shorthorn. We have seen the condition in cattle showing strongly the Hereford characteristics, in those showing equally strong Shorthorn characteristics, and in mixtures of the two. The only case of which we know in purebred cattle was that of the 9 heifers previously mentioned, which were Shorthorns raised under range conditions. Instances of abnormally short-legged range cattle showing Hereford characteristics have been reported in Texas by Lush.[21] Except for shortness of legs, these animals are apparently normal. Lush has given evidence of a hereditary cause of this condition and a history of the admixture of Dexter blood in the foundation animals.

As the deformity is not associated with any particular breed or any particular breeding, while many observations associate it with the feed supply, we are therefore strongly inclined to the theory that environmental rather than hereditary factors are involved.

The number of deformed calves born in the different herds varies greatly. There may be one or two cases only in a herd. In some small herds a total of 10 per cent deformed calves has not been uncommon. One case of an owner's having 5 cows, all of which had deformed calves

in 1930, was reported. On another place in the same vicinity in 1930 a different owner had 5 cows, 4 of which calved in January and February, with all the calves deformed, while the fifth cow gave birth to a normal calf in May.

These cows were again bred in May, 1930, and were kept on the small home ranch until September, when 2 of those having deformed calves in the spring and the one having the normal calf were moved to a pasture where they had access to green feed. The 2 cows kept on the home ranch again had deformed calves in 1931, and the 3 moved to the other pasture

Fig. 5.—Leg bones of an "acorn calf" compared with those of a normal calf, to show the shorter shafts of the former. *A* and *B*, femurs. *C* and *D*, humeri.

had normal calves. Incidentally, there was an abundance of acorns in this field. The following typical reports will give some idea of the incidence of the trouble: 57 calves, 9 deformed; 58 calves, 8 deformed; 100-cow herd, unknown number of calves, 8 deformed; 30 calves, 10 deformed; 800-cow herd, unknown number of calves, 40 deformed.

Ranches reporting a considerable existence of this trouble one year may have none the following year. This is coexistent with better feed conditions. In one instance, 9 deformed calves were observed, all of which were from two-year-old heifers. Other reports indicate that deformed calves may be more liable to be born to heifers than to older cows. It does, however, occur in cows of all ages.

Figure 5 illustrates the short shafts of the bones of one of these calves, born April 8, 1930, as compared with those of a normal calf. Analysis made of one femur from this case showed 49.4 per cent ash on

the dry, fat-free basis, which is normal for the newborn. On macroscopic examination of a longitudinal section of the femur, stained with silver nitrate, the provisional line of calcification and the calcification throughout the bone appeared normal. The blood serum from this calf contained 12.6 mg of calcium and 8.8 mg of phosphorus per 100 cc, which is normal. There was some evidence of beading at the chondrocostal junctions of the ribs. The two known conditions associated with beading of the ribs are scurvy and rickets. The former results from lack of vitamin C; the latter from mineral deficiency complicated by a lack of vitamin D.

The causes of this condition apparently date back into the earlier period of gestation, when the skeleton is being laid down in cartilage and ossification is beginning. According to the evidence, the condition becomes manifest when this period of gestation coincides with poor feed conditions. It is, therefore, usual to find these deformed calves' being born several months later even though their dams are then on good green feed.

SUMMARY AND CONCLUSIONS

It is recognized that the foregoing data are fragmentary and incomplete in many ways. This publication is presented at this time in response to urgent requests by stockmen that the data so far obtained be made available.

Analyses of over 400 samples of range forage collected at different seasons of the year over a two-year period have been presented. These comprised six individual species of plants and also composite samples containing more than one species, representing as nearly as possible the forage as being grazed by the animals at the time the material was collected.

The samples represented the various growth stages of the plants throughout the two-year period from the early green vegetative stages following the first rains to the dry, bleached, and leached forage at the end of the dry season. The analyses show remarkable changes in the nutritive value of the forage plants at various stages of growth and seasons of the year. The dry matter in the forage varies from that of a protein-rich concentrate during the early vegetative stages to that of a poor roughage during the drought period.

The difference in composition between species is more marked than the variation within the species when grown on different areas and the value of a range is dependent in a large measure upon the relative abundance of those species which maintain high nutritive value over a long period of the year.

The outstanding individual species which maintained relatively high nutritive value throughout the year, is bur clover. This is partly accounted for by the fact that the burs are available to livestock even after they have matured and have fallen to the ground.

The annual grasses and broadleaf alfilaria, while valuable early feed, have a comparatively short period when they furnish adequate nutrition. When these species mature and dry, the seeds are largely unavailable and the remaining stems and leaves are deficient in protein and minerals, particularly phosphorus. The red stem alfilaria tends to remain green later in the season than the broadleaf. It is higher in protein and ash and lower in fiber than the broadleaf at corresponding stages of growth. The white stem species appears similar to the red stem in composition.

All of the alfilaria species are remarkable for their high content of silica-free ash and the calcium content is unusually high. The grass species on the other hand are low in calcium and total minerals.

The value of a range cannot be determined solely on the abundance of forage in relation to the number of animals grazing, since severe losses in weight commonly occur during the drought period on ranges containing plenty of dry feed, when this forage is composed of species which do not supply adequate amounts of essential nutrients. The efficient use of ranges depends on the ability of the owner to utilize the various species when they are most valuable or on properly supplementing the forage when it becomes deficient.

By means of chemical analyses of samples from burned and unburned areas an attempt was made to ascertain why the forage on burned areas is more palatable to livestock during the first year following the fire. In one area a decided increase in phosphorus was shown to exist in broadleaf alfilaria and to a less extent in wild oats on the burned area. This was not substantiated in a limited number of samples taken from two other areas with more fertile soil.

In cooperation with the United States Forest Service samples of browse consisting of sweet birch and bitterbrush were analyzed at different stages of growth. A few grass and clover samples were also taken from mountain meadows. This data, together with observations on the condition of the animals, reports of depraved appetite, and other clinical evidence, indicate the existence of nutritional problems in the higher elevations.

The data on the effect of rain on dry forage which was presented in detail in an earlier publication have been augmented and summarized in this paper.

A few tests are included, showing rather large variations in vitamin A content of the liver of range steers at the time of slaughter, depending on their previous feed supply.

The results of five digestion trials with range forage, three of which had been previously published, are reported. These data show the relatively high nutritive value of bur clover, compared to dry grass and alfilaria. They also show that even the dry, bleached, and leached forage may furnish a cheap source of energy for livestock if properly supplemented.

Observations are given on problems connected with reproduction in range cattle, particularly iodine deficiency, high mortality in newborn calves, and the deformity known as "acorn calves." The latter is apparently associated with poor feed conditions at certain periods of gestation.

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APPENDIX

Description of Ranches, Southern Area.—Ranch No. 1 is located southeast of Oakdale in the grassland foothills, where the soil is mainly of fine texture, with relatively few outcropping ledges. It is probably representative of the best grazing land in the San Joaquin Valley. Here, bur clover grows abundantly. Other species of importance are alfilaria, wild oats, brome grass, and various other annuals. In the natural sequence of grazing, the first species available is alfilaria, followed shortly by the grasses. On February 4, 1930, when the first sample was taken, the cattle were grazing largely alfilaria and the grasses. They continued to graze in this manner until April, when the bur clover began to dry. Throughout the remainder of the season, this species constituted the main forage.

The owner of this ranch maintains a breeding herd and keeps the cattle on the home ranch throughout the year. Beef steers from the

vicinity are among the earliest grass-fat steers going to market from April to June.

Ranch No. 2, located east of Merced among the higher timberless foothills of the San Joaquin Valley, in what is known locally as the slate area, produces forage of the same species as those found on ranch No. 1. In 1930, however, there was relatively less bur clover and possibly more wild oats. The sequence of grazing is much the same for the two ranches, but apparently the forage on ranch No. 2 was somewhat later in stage of growth than that on ranch No. 1. A breeding herd is maintained. Steers are finished on the home ranch by supplementing the forage with cottonseed cake and barley and are sent to market shortly after those

Fig. 6.—Area showing transition from timberless to wooded range.

from ranch No. 1. During the summer months the cows and calves are pastured on salt grass in the bottom land of the San Joaquin Valley.

Ranch No. 3 is located on the rolling plains east of Madera. About 60 per cent of the land consists of medium-textured soils, while the remaining portion is heavier, tending toward adobe. On this area the principal species are alfilaria, annual fescue, brome grasses, and pepper grass (*Lepidium dictyotum*). Red stem, white stem, and broadleaf alfilaria are all present, the last-named species, however, predominates and practically no wild oats are found. On the heavier soil, in favorable years, a very good growth of bur clover is produced. In the sequence of grazing on the loam portion of the ranch, the alfilaria is the first forage to appear; and cattle graze this until other forage is available. With the coming of the other species, cattle show a preference for the grasses, pepper grass, and white stem alfilaria until May, when the bur clover begins to dry. This species then constitutes the principal forage until

it is all consumed; subsequently the principal forage is alfilaria. No breeding herd is maintained on this ranch. Yearling heifers and steers are purchased in the fall and winter months, pastured on the green forage in the spring, and finished on grass and cottonseed cake in the spring and summer months.

Ranch No. 4, located northeast of Madera at a somewhat higher elevation than No. 3, has dark-brown soil of medium texture and is in the locally termed schist area. The forage growth is considerably ranker than on any of the previous three ranches, and a greater percentage of it consists of the grass species. In grazing value and sequence of grazing, ranch No. 4 does not differ greatly from the red-loam portion of

Fig. 7.—A range in the locally termed granite area. Example, ranch No. 6.

No. 3, although the method of grazing gives it some advantage in the chemical analyses. The cattle were kept in the granite foothills, and the sampling pasture was reserved for fall and winter grazing, the better forage thus being left available for sampling in the late summer and fall. In 1930, moreover, the bur clover crop on this particular ranch was the best in years. Cattle are marketed as calves.

Ranch No. 5, in the rolling plains east of Fresno, at about the same elevation as No. 3, has soil relatively light in color and texture. The ranch is typical of a rather large area in the San Joaquin Valley. The forage consists of broadleaf alfilaria and annual grasses. Only a few head of steers were on this pasture in the early spring months of 1930, most of it being saved for fall and winter feed.

Ranch No. 6, a grass and alfilaria range located east of Madera, contains some tree growth. The soil, light in color, with granite outcrop-

pings, is in the area known locally as granite. The forage here is usually ranker than most of that found in the true grassland areas. The earliest forage is the alfilaria, chiefly the broadleaf species, followed by the grasses, including brome grass, wild oats, fescue, and other annuals. After the feed dries, alfilaria is probably preferred, although the cattle necessarily consume considerable quantities of the grass species. Cattle are kept on the ranch from October to June. For the remainder of the year, some of them are on salt grass pasture in the valley, and some are taken to the National Forest in the Sierra Nevada Mountains.

Ranch No. 7, near Coalinga, is typical of the alfilaria land on the west side of the San Joaquin Valley. The range is hilly and treeless. The soil is Kettleman loam and clay loam. Red stem alfilaria is by far the most valuable forage species, although brome grass, foxtail (*Hordeum murinum*), and pepper grass furnish valuable forage in the early green feed season. Only 5.24 inches of rain were reported at Coalinga between July, 1929, and June, 1930, and because of the drought the forage was so closely grazed that no samples could be obtained from the open range after May, 1930. The sample collected on June 14 came from a small fenced area which had not been pastured. At the time this sample was taken cattle in fair condition were still on the range. In normal years, cattle are kept on the home ranch throughout the year. A breeding herd is maintained, and steers are marketed at three years of age.

Ranches 8 and 9 are located in the foothills southeast of Porterville. Ranch No. 8 is in the timberless foothills, while No. 9 is in the wooded granite hills, at a somewhat higher elevation. The principal forage species on the former ranch is red stem alfilaria, with some pepper grass, brome grass, and foxtail; in years of sufficient rainfall, bur clover is abundant. Ranch No. 9 is largely a grass range, although some red stem alfilaria is found. Between July, 1929, and June, 1930, in the Porterville section, only 5.48 inches of rain fell, most of it coming in January and February. In consequence, there was practically no bur clover, and the alfilaria crop was extremely short and dried quickly. By the middle of March, the forage on the timberless foothills was dry, and at this time a hail and rain storm destroyed practically all the remaining forage. In the wooded area, samples could be obtained until June. Few breeding herds are maintained in this area, and most animals are imported in the fall and winter as feeders, to be marketed in the spring and summer of the following year. These cattle are finished on grass, cottonseed cake, and barley.

Description of Ranches, Northern Area.—Ranch No. 10, located in the timberless foothills southwest of Red Bluff, is typical of the best

grazing land in the Sacramento Valley. The south slope on which the samples were taken is a shale formation, with occasional limestone outcroppings containing sea shells. Many different forage species are found intermixed, but the principal ones are bur clover and wild oats. From February to May, the alfilaria species constitute the principal forage. Cattle are kept on the home ranch throughout the year. Steers are fattened on the grass alone and are sent to market as two-year-olds, normally in June and July.

Ranch No. 11 is in the foothills west of Red Bluff, where the soil is not so heavy. There is no red stem or white stem alfilaria, nor is the bur clover so plentiful as on Ranch No. 10. The principal forage species are

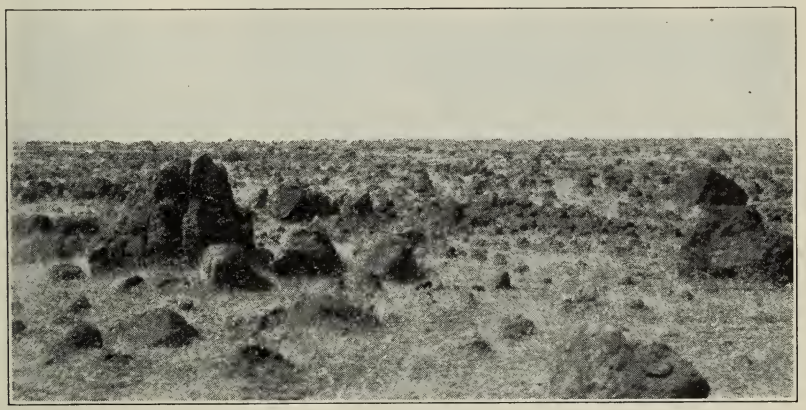

Fig. 8.—The rocky plain range east of Red Bluff. Example, ranch No. 12.

bur clover, broadleaf alfilaria, and various grass species, including wild oats and soft chess. In 1930 the cattle on this ranch showed a preference for bur clover throughout the season. According to the owner, this is not a normal grazing habit, the cattle usually taking alfilaria early, then the grass species, but no considerable amount of bur clover until it begins to dry. In 1930 some cattle were kept on the home ranch the entire season, but most of them were pastured in mountain meadows in northern California and Oregon from June to October. Steers usually go to market in August and September.

Ranch No. 12 is representative of the best grazing land of the lava foothills east of Red Bluff. Sample No. 64 collected in March was taken on a slightly poorer feed area adjoining it. The forage growing on ranch No. 12 bears a marked contrast to that found on Nos. 10 and 11. None of the forage except scattered patches of wild oats and brome grass exceeded two or three inches in height in 1930, and it was highly inter-

mixed with Napa and star thistle. In grazing, the cattle roll the small rocks, which partly cover the surface of the ground, around with their noses and eat the forage that grows tallest around the edges of the rocks. This sight is very common when cattle are grazing in this area. The principal forage species are broadleaf alfilaria, foxtail, brome and fescue grasses, thistle, and some bur clover. No definite sequence of grazing was noted here, although cattle evidently preferred bur clover throughout the year. Cattle are kept on the home ranch for about eight or nine months of the year, and are pastured in the mountain meadows

Fig. 9.—A typical wooded hill range west of Red Bluff. Example, ranch No. 13.

during the remaining time. Steers usually are marketed from the mountain range in August and September as two and three-year-olds.

Ranch No. 13, taken as typical of the wooded hills west of Red Bluff, is largely a grass range with smaller amount of broadleaf alfilaria. The latter, which constitutes the better feed, is decidedly preferred by the cattle during most of the season. The forage here grows much ranker than that on the other three ranches previously described, and is relatively more abundant. Few cattle were on the ranch during the greater portion of 1930, so that the better feed was conserved for fall grazing. Usually the cattle remain on the home ranch eight or nine months of the year; for the remainder of the season, they are on a summer mountain meadow range.

Description of Ranches, Central Area.—Ranch No. 14 is located in the Marysville Buttes area where the soil is dark gray or black in color and volcanic in origin. The range is of the open timber type; and the

forage is chiefly bur clover, broadleaf alfilaria, wild oats, soft chess, red brome, and fescue. The same owner uses this ranch in conjunction with ranch No. 15, the latter usually being the cow and calf range and the former the stocker cattle range during the winter and spring months. In the summer, from June to October, all the cattle are usually taken to the sweet birch range in the Tahoe National Forest. During the season of 1930, however, two- and three-year-old steers were fattened on ranch No. 14, where the forage is regarded by the owner as slightly superior to that on ranch No. 15.

Ranch No. 15, in the wooded foothills southeast of Marysville, has reddish, gravelly soil. The forage species are the same as those found on ranch No. 14. In fact, no difference can ordinarily be noted between the two ranches in respect to quantity of the feed and the forage species. Ranch No. 15 is a rougher range, and in 1930 it was very heavily grazed. Both these ranches have about the same sequence of grazing; first alfilaria, then the grasses, and then bur clover, with the other species from the time the clover begins to dry throughout the remainder of the season. In 1930, possibly because of the general shortage of feed, cattle ate considerable bur clover in the green stage.

Ranch No. 16, located south of Folsom in the timberless foothills, has a soil reddish in color and somewhat gravelly. The principal forage species are bur clover, broadleaf alfilaria, and the annual grasses. Cattle are kept on the home ranch from November to June. For the remainder of the season they are pastured on browse and meadowland in the mountains. This ranch is typical of the better grazing land in the district. A breeding herd is maintained, and beef animals are finished by supplementing the forage with cottonseed cake. The sequence of grazing is much the same as on ranches 14 and 15, except that cattle eat bur clover in all stages of growth.

Ranch No. 17 is located north of Ione in the brushy and wooded foothills. The south slope upon which the sampling area was located had been cleared of all tree and brush growth. The owner believes that this practice has resulted in an improvement of the range: not only has it apparently increased the quantity of feed, but it has brought about a replacement of the less desirable with the more desirable species, principal among which are bur clover, alfilaria, and the grasses. In addition to the broadleaf alfilaria, which is common on most ranges, this ranch has considerable red stem and some white stem alfilaria. In 1930, very heavy grazing occurred on it, and by fall the bur clover was depleted. The sequence of grazing is much the same as on ranch No. 16 except that cattle were not observed eating bur clover until it had begun to dry. The

owners keep their herds on several different ranches and market their cattle as calves.

Ranch No. 18 is located near ranch No. 17 in the wooded foothills, where the soil is red in color and gravelly. The ranch is considered to be slightly inferior to ranch No. 16, although the forage is practically the same except that it is possibly more abundant and ranker. The sequence of grazing on both places is very similar.

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